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PHASE I INSPECTION REPORT. NATIONAL DAM SAFETY PROGRAM, BOONTON--ETC(U)
MAY 78 J J WILLIAMS DACW61-78-C-0052

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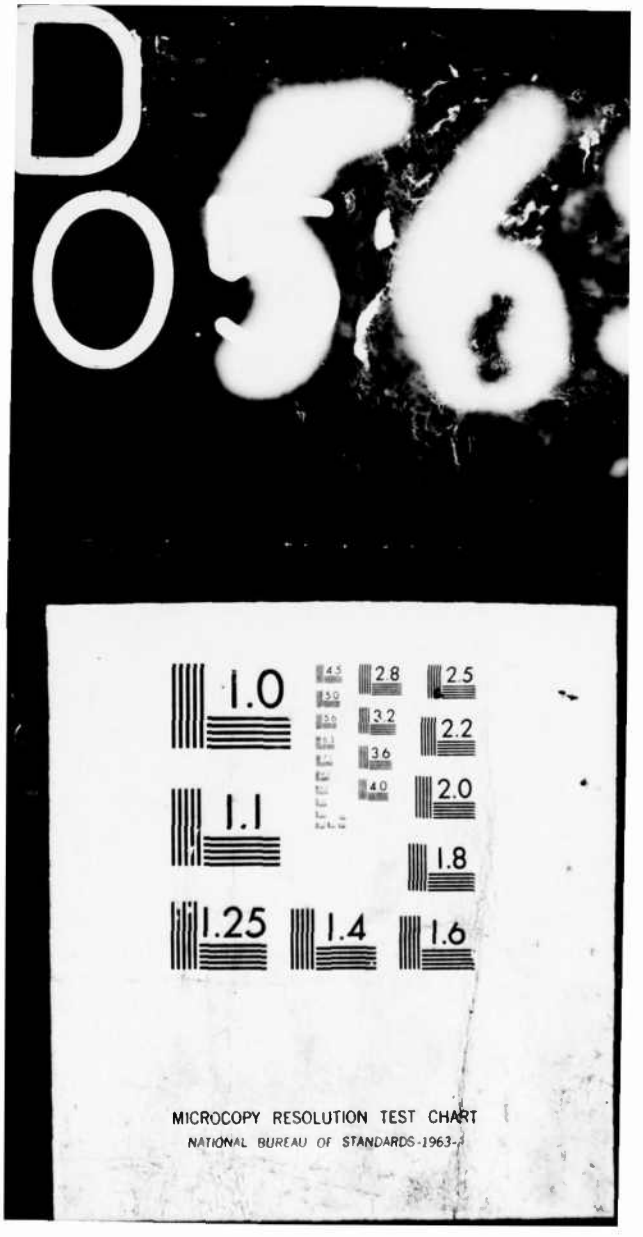
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PASSAIC RIVER BASIN

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MORRIS COUNTY

NEW JERSEY

BOONTON DAM

&

PARSIPPANY DIKE

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

NJ00354 & NJ00546

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

MAY 1978

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

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18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

National Dam Safety Program
Dam Inspection Report Phase I
Boonton Dam, N.J.
Parsippany Dike, N.J.
Dams - N.J.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE-2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

3 JUL 1978

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Boonton Dam and Parsippany Dike Dam in Morris County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given on the first three pages of the report.

Based on visual inspection, available records, calculations and past operational performance, Boonton Dam and Parsippany Dike are judged to be in good condition. However, the spillway is considered to be inadequate as the Probable Maximum Flood (PMF) would overtop the dam embankment by 1.1 feet (spillway gates down) or 1.5 feet (spillway gates up). With gates down, the spillway will accommodate approximately 1/2PMF. The dike would not be overtopped under either PMF or 1/2PMF. To insure adequacy of the structures, the following actions, as a minimum, are recommended:

a. Hydrologic and hydraulic investigations and engineering studies should be initiated within three months of the date of approval of this report to determine corrective action required to increase the capacity of the spillway and obtain adequate freeboard to prevent overtopping of the dam. Construction of an improved spillway should commence in calendar year 1979. An engineering study and necessary modifications to automate the operation of the bascule gates should also be accomplished within this time frame. Due to the potential for overtopping of the dam, a detailed emergency operation, drawdown and warning system should be developed by the owner within the next two months.

b. Engineering investigations should be initiated within four months of the date of approval of this report to determine the need for post-

tensioned tendons, to design the necessary slope protection repairs, to investigate the condition of the gates, to install piezometers to monitor pore pressures, to monitor the seepages from the south embankment and dike, and to investigate the cause of the sinkholes downstream of the gravity dam. Any corrective action deemed necessary as a result of these investigations should be initiated during calendar year 1979.

c. Within one year of the date of approval of this report, the below noted actions should be initiated and substantially completed:

(1) Removal of refuse dump at toe of dam.

(2) Removal of trees and brush from the embankment and replacement thereof with suitable ground cover.

(3) Clean or replace screens at intakes.

(4) Establish regular observation of minor surface subsidences in earth embankment extensions and seepages at surface cracks in dam.

Two copies of the report are being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congresswoman Millicent Fenwick of the Fifth District. Under the provisions of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, thirty days after the date of this letter.

Additional copies of this report may be obtained from the National Technical information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely yours,

Harry V. Dutchyshyn

1 Incl
As stated

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

Cy Furn:
Mr. Dirk C. Hofman, P.E.
New Jersey Dept. of Environmental Protection

PASSAIC RIVER BASIN

Name of Dam: Boonton Reservoir Dam
County and State: Morris County, State of New Jersey
Inventory Number: NJ 00354

Name of Dam: Parsippany Dike
County and State: Morris County, State of New Jersey
Inventory Number: NJ 00546

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by: O'Brien & Gere Engineers, Inc.
Justin & Courtney Division

For: United States Army Engineer District, Philadelphia
United States Custom House
2nd & Chestnut Street
Philadelphia, Pennsylvania 19106

Date: May 14, 1978

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam: Boonton Reservoir Dam
Parsippany Dike

State Located New Jersey
County Located Morris County
Stream Rockaway River
Date of Inspection April 14, 1978

ASSESSMENT OF GENERAL CONDITIONS

Boonton Reservoir Dam, according to construction drawings, is a masonry gravity structure about 2,150 feet long and 120 feet high at its' maximum section. A 300 foot gated spillway is constructed at the northern end of the structure. The masonry dam is extended on both ends by earth embankments. Parsippany Dike, a 3,200 foot long earth dike with a maximum height of 30 feet is located at the southern end of the reservoir and completes the impoundment facility.

A visual inspection of the reservoir complex revealed no external evidence of structural or embankment instability. The stone facing on the non-overflow section of the masonry dam is in excellent condition. However, items requiring remedial work or further investigation were noted and are described within this report.

Limited hydrological and hydraulic investigations of the watershed area and dam were performed. In accordance with the Recommended Guidelines for Safety Inspection of Dams, the Probable Maximum Flood (PMF) was developed and routed through the reservoir. The results indicate that the PMF would overtop the non-overflow section of the masonry dam and earth embankments by 1.1 feet with the spillway gates in the lowered position and 1.5 feet with the gates in the raised position; the PMF, however, would not overtop the dike. Further analysis indicates that the spillway could accommodate approximately the ½PMF without overtopping the dam and earth extensions provided that the bascule gates are in the lowered position.

Stability analyses of the masonry gravity dam (non-overflow section) were performed with consideration of seven different loading conditions (See Appendix A-48). The analyses indicate that the resultant falls slightly outside the middle third under normal loading conditions and significantly outside the middle third under severe loading conditions. Tensile stresses are developed in the upstream face under all loading conditions analyzed. The analysis also indicates that the structure appears safe relative to sliding under the assumed conditions.

O'BRIEN & GERE ENGINEERS INC.
JUSTIN & COURTNEY DIVISION

John J. Williams

John J. Williams, P.E.
Vice President

Based on visual inspection, available records, calculations and past operational performance, Boonton Dam and Parsippany Dike are judged to be in good condition. However, the spillway is considered to be inadequate as the Probable Maximum Flood (PMF) would overtop the dam embankment by 1.1 feet (spillway gates down) or 1.5 feet (spillway gates up). With gates down, the spillway will accommodate approximately $\frac{1}{2}$PMF. The dike would not be overtopped under either PMF or $\frac{1}{2}$PMF. To insure adequacy of the structures, the following actions, as a minimum, are recommended:

a. Hydrologic and hydraulic investigations and engineering studies should be initiated within three months of the date of approval of this report to determine corrective action required to increase the capacity of the spillway and obtain adequate freeboard to prevent overtopping of the dam. Construction of an improved spillway should commence in calendar year 1979. An engineering study and necessary modifications to automate the operation of the bascule gates should also be accomplished within this time frame. Due to the potential for overtopping of the dam, a detailed emergency operation, drawdown and warning system should be developed by the owner within the next two months.

b. Engineering investigations should be initiated within four months of the date of approval of this report to determine the need for post-tensioned tendons, to design the necessary slope protection repairs, to investigate the condition of the gates, to install piezometers to monitor pore pressures, to monitor the seepages from the south embankment and dike, and to investigate the cause of the sinkholes downstream of the gravity dam. Any corrective action deemed necessary as a result of these investigations should be initiated during calendar year 1979.

c. Within one year of the date of approval of this report, the below noted actions should be initiated and substantially completed:

(1) Removal of refuse dump at toe of dam.

(2) Removal of trees and brush from the embankment and replacement thereof with suitable ground cover.

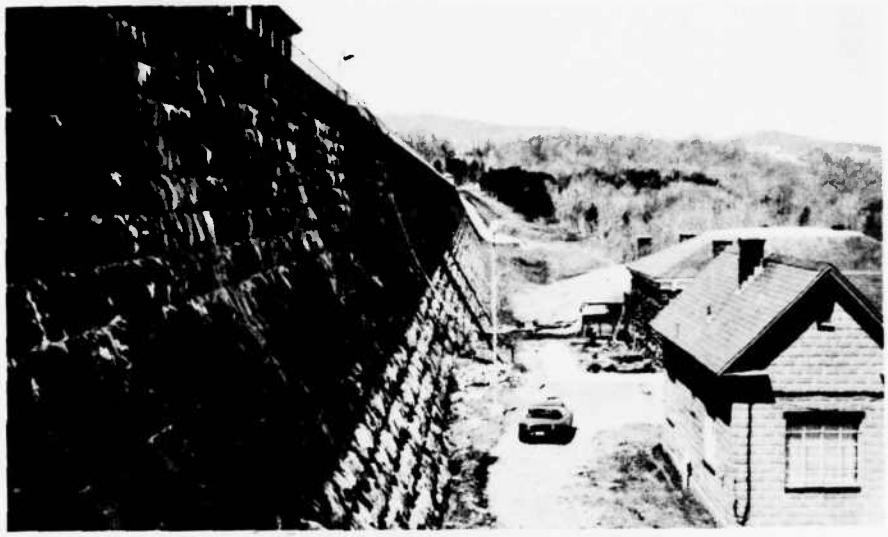
(3) Clean or replace screens at intakes.

(4) Establish regular observation of minor surface subsidences in earth embankment extensions and seepages at surface cracks in dam.

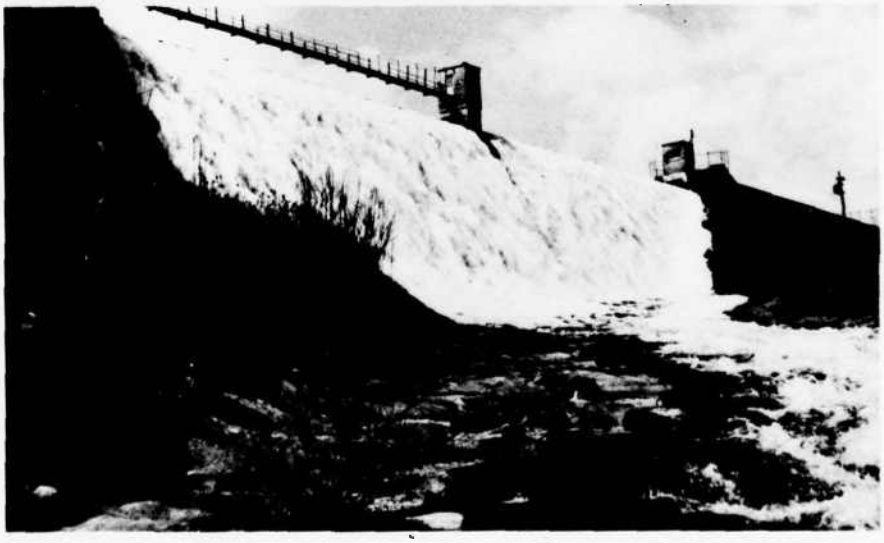
APPROVED: Harry V. Dutchyshyn

HARRY V. DUTCHYSHYN
Colonel, Corps of Engineers
District Engineer

DATE: 3 July 1978



VIEW ALONG DOWNSTREAM FACE OF DAM



OVERFLOW SPILLWAY AND DOWNSTREAM CHANNEL

TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAMS BOONTON RESERVOIR DAM ID# NJ00354
PARSIPPANY DIKE ID# NJ00546

SECTION I - PROJECT INFORMATION

1.1 GENERAL

a. Authority - This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with contract #DACW 61-78-C-0052 between O'Brien and Gere Engineers, Inc., Justin and Courtney Division, and the United States Army Corps of Engineers, Philadelphia District.

b. Purpose of Inspection - The purpose of this inspection is to evaluate the structural and hydraulic conditions of Boonton Reservoir Dam, Parsippany Dike, and appurtenant structures, and to determine if the dam or dike constitute a hazard to human life or property.

1.2 PROJECT DESCRIPTION (Information was provided by Jersey City Water Works)

a. General - Boonton Reservoir Dam and Parsippany Dike are located on the Rockaway River; the axis of the main dam intersects the southern corporate limits of the town of Boonton in Morris County, New Jersey. The dam and dike are owned and operated by the Jersey City Water Works and are used to store and supply water for the community of Jersey City, New Jersey. Construction of the impoundment and water intake works began in 1892, and the entire project was completed in 1905.

The main dam is predominantly a masonry gravity structure (cyclopean masonry construction) extended at each end by earth embankments which tie into the abutments. The spillway of the masonry dam is an overflow structure equipped with a crest hinged (Bascule) gate which is supported at midpoint by a concrete and masonry pier. Parsippany Dike is an earthen structure with a concrete core wall; the dike is located at the southern end of the reservoir. The upstream face of the dike consists of riprap covered with a grout surface.

In order to meet system demands, water is withdrawn from the reservoir through four gates located at two levels of an intake tower. Four butterfly valves located in the lower gate house structure at the toe of the dam are used to control the flow. Renovations are underway to automate the water supply system.

Two forty-eight inch diameter pipes are located through the base of the masonry dam and are used periodically to flush sediment from the reservoir bottom.

Bascule gates installed on the spillway crest in 1955 are normally raised in the spring of each year to increase reservoir storage. The gates are lowered in the fall when additional storage is not required.

Routine inspection of the dam is conducted by operating personnel. No flood warning system is in existence.

b. Dam Size and Hazard Classification - The maximum height of the dam is approximately 120 ft.. The reservoir volume to the top of the dam is about 32,000 acre feet. Therefore, the dam is in the large size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

The Boonton Reservoir Dam is located upstream of a residential community and a significant loss of life and damage to property could be expected if the dam were to fail. Therefore, the dam is in the high hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams. The spillway design flood required for hydraulic analysis is the Probable Maximum Flood (PMF).

c. Dike Size and Hazard Classification - The maximum height of the dike is approximately 30 ft.. The reservoir volume within this range is about 14,000 acre feet. Therefore, the dike is in the intermediate size category as defined by the Recommended Guidelines for Safety Inspection of Dams.

Parsippany Dike is located adjacent to a commercially developed area and a significant loss of life and damage to property could be expected if the dike were to fail. Therefore, the dike is in the high hazard category as defined by the Recommended Guidelines for Safety Inspections of Dams. The design flood required for hydraulic analysis is the Probable Maximum Flood (PMF).

1.3 PERTINENT DATA

a. Drainage Area - According to United States Geological Survey data, the total drainage area contributing to Boonton Reservoir is about 119 square miles. Several impoundments are located within the drainage area which serve to reduce inflow to the reservoir.

b. Discharges at Damsite - According to the records of the Jersey City Water Works (J.C.W.W.) average demand varies between 56

and 62 mgd with a peak demand of 75 mgd. Spillway flows, with the reservoir at maximum pool elevation, (310.25), are approximately 11,000 cfs and 5,000 cfs with gates in the lowered and raised positions respectively. The maximum average daily discharge according to J.C.W.W. records dating from January 1950 was about 500 cfs and occurred on April 8, 1969. The State of New Jersey DEP requires a minimum discharge of 7 mgd (11 cfs) for low flow augmentation downstream.

c. Elevations (above MSL) (from drawings supplied by J.C.W.W.)

Top of masonry dam and earth embankment - 310.25
Spillway crest (bascule gates lowered) 305.25
(bascule gates raised) - 307.25
Top of dike at southern end of reservoir - 312.25

d. Reservoir Data (from USGS Quad Sheets - 7.5 minute series and drawing provided by J.C.W.W.)

Storage @ maximum pool (el. 310.25) - 32,000 ac.ft.
Storage @ spillway crest (el. 305.25) - 28,000 ac.ft.
Storage @ spillway crest with bascule gates raised (el. 307.25) - 29,500 ac.ft.
Surface area @ maximum pool (el. 310.25) - 850 ac.
Surface area @ spillway crest (el. 305.25) - 800 ac.

e. Dam Data (from drawings supplied by J.C.W.W.)

Masonry Dam

Type - masonry gravity (cyclopean masonry construction)
Length - 2,150 feet
Height - 120 feet
Top Width - 17 feet
Side slopes - upstream - 1 horizontal:20 vertical (below el. 255), downstream - .56 horizontal:1 vertical (below el. 297.75)

Earth Embankment Extensions (from drawings supplied by J.C.W.W.)

Type - earth embankment
Length- south embankment - 500 feet, north embankment 600 feet
Height - 45 feet maximum (estimated from plan drawings)
Top Width - 17 feet (estimated)
Side slopes - 2 horizontal:1 vertical (estimated from plan drawings)
Impervious Core - No information available.
Cutoff - No information available.

Dike At Southern End of Reservoir (Parsippany Dike)
(from drawings supplied by J.C.W.W.)
Type - earth embankment
Length - 3,200 feet
Height - 30 feet maximum (estimated from plan drawings)
Top Width - 12 feet
Side Slopes - 2 horizontal:1 vertical
Impervious Core -concrete (to el. 306.75)
Cutoff - concrete (to depth determined by the Engineer during construction)

f. Outlet Data - (from drawings supplied by J.C.W.W.) A water intake tower is located at the masonry dam about 200 feet from the south end. The tower consists of parallel risers each with a 4 foot by 4 foot gated opening at elevation 268.75 and a 8 foot by 4 foot gated opening at elevation 259.75. Flow from the intake tower is regulated by four butterfly valves located at the downstream toe of the dam and is released to the water supply aqueduct supplying Jersey City. (See Figure 6)

Two forty-eight inch diameter pipes, extending through the masonry dam are used to flush bottom sediment deposits. The invert for the intake is at elevation 205 and the discharge elevation is 201.88. Flow is regulated by two thirty-six inch valves in series in each pipe (See Figure 5)

g. Spillway Data (from drawings supplied by J.C.W.W.)
Type - concrete overflow weir
Length - 300 feet
Gates - bascule
Crest Elevation - bascule gates lowered 305.25
bascule gates raised -307.25
Downstream Channel - The downstream channel is surfaced with granitic type rock set in grout. An energy dissapator consisting of large rocks set in place has been constructed about 400 feet downstream of the dam.

h. Flood Elevations at the Dam and Dike (Local Datum) Flood crest elevation were developed for the probable maximum flood with the bascule gates in the lowered and raised positions.(See Hydraulic/HYdrologic Section)

PMF Elevation (feet)
--bascule gates lowered - 311.3
--bascule gates raised - 311.7

i. Engineering Data - The engineering data made available for review of Boonton Reservoir Dam included:
--Survey sheet of dam and impoundment dated April 6, 1915.

--Sketch showing section through sluice way and proposed new 36" gates at end of same dated 1914.

--Parsippany Dike, general plan and cross-sections dated August 1, 1902.

--Main Dam at Boonton, plans of intake and foundations of lower gate house approved April 14, 1902.

--Plan showing layout of dam and lower gate house with new piping installation; Boonton, New Jersey dated September 21, 1934.

The drawings reproduced herein were provided by the J.C.W.W. but do not necessarily represent existing conditions due to lack of updating.

SECTION 2 - VISUAL INSPECTION

2.1 FINDINGS

a. General - The field inspection for Boonton Dam, Parsippany Dike and reservoir, was conducted on April 14, 1978. The air temperature was about 50°F with partly cloudy skies. Wind speed was about 30 mph at reservoir surface. The depth of water flowing over the spillway at the time of inspection was about 0.2 feet.

No underwater areas were inspected.

b. Dam - The masonry dam is a gravity structure of cyclopean masonry. The alignment of the dam crest appeared straight, which would indicate no significant settlement or lateral movement of the structure. The large granitic stones used for the facing of the structure appear to be in excellent condition. Some evidence of joint deterioration was found in the stone coping on the south side of the masonry dam.

The concrete serviceway along the crest is cracked and has deteriorated in several areas. Pipe extensions, that appear to be filled with grout, were found at three locations along the serviceway. However, according to the owner's representative, no known internal grouting of the structure has taken place.

The bascule gates located on the overflow spillway were in the lowered position during the inspection. According to J.C.W.W. personnel, the gates are operated by a manually controlled hydraulic system and only raised during normally high runoff periods to provide additional storage capacity during the summer months.

The gate house located above the intake tower contains the controls for the four sluice gates. The equipment is antiquated, and one gate which has been removed is corroded and in very poor condition. Operating personnel indicated that it was difficult to remove the gate: The shaft had to be flame-cut in order to complete the task. It was also stated that the screens in the intake area are unable to be cleaned and cannot be removed.

Flowing water was located at the toe of the masonry dam (non-overflow section) at the south embankment. The exact source of the flow was not apparent; however, flow was clear and estimated at two to three gallons per minute. The drain channel extends for about 150 feet and terminates at an area where random fill and trash has been dumped. This fill or "dump" is located between the lower gate house and the toe of the dam.

Water was observed seeping through the downstream face of the masonry dam (non-overflow section) at three locations between the south embankment and the spillway. The seep is sufficient to keep the stone damp. The fill adjacent to the downstream toe for most of the length of the dam is in a moist condition and readily settles when subject to foot traffic.

A crack in the jointing was located on the downstream face about 300 feet from the north embankment. Water is seeping from the crack at a rate to keep the stone moist.

A number of sinkholes in the toe area to the north of the spillway were noted. The largest concentration appeared in an area approximately thirty feet by twenty feet. Operating personnel indicated that they were aware of this condition and have monitored the holes in an effort to detect indications of flowing water. The sinkholes have apparently existed for a long time and may have occurred soon after construction was completed. Another sinkhole was located at the toe of the masonry dam (non-overflow section) just south of the bottom discharge structure. The hole was about three feet deep and twenty inches in diameter and appears to be a result of surface drainage. No evidence of water was detected in any of the sinkholes.

Some vegetation in the form of vines was observed on the downstream face of the dam. In addition, the toe area was fairly well covered with brush and small trees.

Water was observed discharging from a small pipe located in the bottom discharge structure. According to operating personnel, the discharge is from the valve chamber located within the dam (see Figure 5)

c. Earth Embankment Extensions - The masonry dam (non-overflow section) is extended on each end by earth embankments. The downstream slope of the embankments are covered with grass and no indication of erosion was noted. The south abutment, however, contained a number (nine were counted) of holes apparently caused by burrowing rodents. Operating personnel are aware of this problem and are actively engaged in a program to eliminate the rodents.

The upstream slope of the embankment is protected by a facing of grouted riprap. Failure of this facing was noted at a few areas along both embankments. A subsidence in the riprap facing, extending into the top of the embankments, is noticeable in both earth embankment extensions, approximately fifty feet from either end of the masonry dam (non-overflow section). In both cases, the subsidence is not appreciable.

d. Parsippany Dike Parsippany Dike, an earthen structure approximately 3,200 feet long, is located at the southern end of the reservoir. The upstream slope is protected by riprap covered with a grout surface. Wave action has apparently eroded the fill just below the grouted surface material, and bridging of the grout surface is evident. This bridging has broken down in certain areas exposing the stone and random fill. A few small holes, probably caused by rodents, and two small tree stumps were also noted along the crest.

The downstream slope is grass covered along most of its length. A well established growth of brush and fairly large sized trees are located on the downstream slope at the right end (looking toward the reservoir) of the dike. Seepage and moisture, at the toe of the dike, were noted in localized areas for a total of about one half the embankment length.

e. Reservoir Area - The reservoir perimeter is uninhabited and access to the reservoir is discouraged by fencing.

f. Downstream Channel - The spillway channel is lined with rock set in place. An energy dissapator is constructed about 400 feet downstream of the dam. The immediate area below the dam is sparsely populated, however, the community of Lower Montville is located about three miles downstream of dam and has a considerable population that could be exposed to flooding.

2.2 EVALUATION

The masonry dam (non-overflow section) shows no significant external signs of deterioration. The large surface stones used in the cyclopean construction, the joints and the joint material all appear to be in excellent condition. However, the upstream surface material of the earth embankments has collapsed in certain areas of the dike and is showing signs of deterioration in areas along the extensions of the main dam.

SECTION 3 - HYDROLOGY AND HYDRAULICS

In accordance with the criteria established by the Recommended Guidelines for Safety Inspection of Dams, the Spillway Design Flood used to evaluate the hydraulic capabilities of Boonton Reservoir Dam is the Probable Maximum Flood (PMF).

The PMF was calculated from probable maximum precipitation data as published in Hydrometeorological Report No. 33.

The rainfall data was modified to account for basin size and storm characteristics by using standard reduction factors. The HEC I computer program was employed to develop the inflow hydrograph and flood route the PMF through the reservoir facility. Two separate routings were performed: The results indicate that the dam and earth embankment extensions would be overtopped by 1.1 feet when the bascule gates are in the lowered position and 1.5 feet when the bascule gates are in the raised position. The peak discharges are about 26,900 cfs and 26,800 cfs respectively. The analysis also indicates that the PMF would not overtop the dike based on the crest elevation shown on the drawings provided (see Figure 7)

A drawdown analysis was performed to estimate the time required to drain the reservoir by means of the bottom discharge structure (2 - 48 inch diameter pipes). The water surface was assumed to be at the spillway crest (bascule gates lowered) with no inflow to the reservoir. Under these conditions, the estimated time to drain the reservoir is about twenty-five days. This represents a minimum time with no consideration given to downstream constraints such as safe discharge velocities or flows.

SECTION 4 - STRUCTURAL STABILITY

4.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observation - No significant indications of structural instability were noted during the inspection of the masonry gravity dam, earth embankment extensions or dike.

b. Design and Construction Data - Drawings, design data and construction history relatlve to the Boonton Dam and Parsippany Dike were provided by J.C.W.W.. Cross section drawings of the masonry dam were made available, and the maximum section was used for analyses. Information pertaining to the design of the spillway apparently is not available.

c. Operating Records - Inspection of the operating records of the J.C.W.W. revealed reservoir water surface elevations dating from to 1950. The maximum water surface elevation recorded for the period of record is 307.89. Operating personnel also reported that layers of ice up to twenty-four inches in thickness had developed during severe winter weather conditions.

d. Post Construction Changes - The original piping arrangement for the water supply system was revised in 1934. Renovations are underway to automate the water supply system.

Crest hinged (Bascule) gates were installed on the existing spillway in 1955 to increase reservoir storage. Under normal operating procedures, the gates are raised in the spring and lowered in the fall.

e. Seismic Stability - The dam is located in the Triassic Highlands physiographic subprovince of northern New Jersey and is founded on fine to medium grained, red sandstone and shale of the Triassic Newark Group, Brunswick formation (lithofacies), as described on the Geologic Map of New Jersey, 1950.

Rock outcrops were observed downstream of the masonry dam in the discharge area and consists of medium thick to thin beds of red shale and sandstone dipping upstream at a shallow angle. No bedrock was observed in the dike area location at the southern end of the reservoir.

Although the dam is in proximity of the Ramapo fault, which trends northeast-southwest, crossing the Rockaway River approximately one mile upstream, there does not appear to be any seismic stress related problems within the structures inspected. However, since

recent studies have indicated an increase in recorded seismic activity along the Ramapo fault, consideration should be given to its possible effects on the stability of the Boonton Reservoir Main Dam structure.

The dam and dike are located in seismic zone 1, as shown on the Seismic Zone Map of the Contiguous United States. Under the Recommended Guidelines for Safety Inspection of Dams, further analysis relative to seismic loading is not required for Phase I investigation. However, due to the proximity of the Ramapo fault, a seismic analysis was conducted using the more conservative Seismic Zone 2 coefficient.

Factual data pertaining to foundation investigations are not available. Therefore, design assumptions concerning foundation rock characteristics were based on information obtained from general geologic maps and field observations made during the course of the inspection.

f. Evaluation - Analyses of the structural stability of the non-overflow section of the main dam considered seven different loading conditions. The results of these analyses are summarized in the appendix. The resultant falls slightly outside the middle third for normal loading conditions. Under severe loading conditions (earthquake and PMF), the resultant falls a significant distance outside the middle third of the base.

SECTION 5 - ASSESSMENT/RECOMMENDATIONS/REMEDIAL MEASURES

5.1 ASSESSMENT

The spillway is incapable of passing the PMF: overtopping of the non-overflow sections of the main dam would occur for about forty hours and considerable damage to the earth embankment extensions could reasonably be expected. However, the spillway appears to be capable of passing the ½PMF providing the bascule gates are in the lowered position. Parsippany Dike would not be overtopped by the PMF based on the hydrological/hydraulic computations made.

The manual operation of the spillway gates significantly reduces the spillway capacity from that proposed in the original design and severely limit the ability of the spillway to pass major flows without overtopping the non-overflow sections of the main dam.

The masonry gravity dam (non-overflow section) is considered structurally adequate under normal loading conditions, although the resultant of forces falls slightly outside the middle third. However, under severe loading conditions such as earthquake and PMF, the resultant of forces falls a significant distance outside the middle third.

The earth embankment extensions and dike appear to be stable although the upstream facing of both the main dam embankment extensions and the earth dike are in need of remedial work.

Seepage was noted at the north end of the south embankment and in localized areas along the dike. These flows are not being monitored according to operating personnel.

Sinkholes were located in the toe area downstream of the masonry gravity dam (non-overflow section). A detailed investigation of the sinkholes has not been performed.

There is no procedure for drawdown under emergency conditions, nor is there any system for flood warning.

5.2 RECOMMENDATIONS/REMEDIAL MEASURES

Additional investigations, remedial measures and recommended actions are as follows:

1. Install post-tensioned tendons to eliminate tension in the upstream face of the masonry dam and increase the overall structural stability.

2. Excavate the sinkhole area, located near the downstream toe of the masonry gravity dam (non-overflow section), to determine the cause of the depressions and need for remedial work.

3. Implement a maintenance program to repair all sections of the upstream facing of the earth embankment extensions and dike that have collapsed or show significant deterioration; or, in, lieu of this, place riprap protection on the upstream face.

4. Develop an emergency drawdown procedure that could be accomplished in a minimum time taking into consideration all constraints relating to allowable downstream flows and velocities. This could include a flood warning system.

5. Continue program to protect against damage due to burrowing rodents.

6. Remove refuse dump at toe of dam.

7. Remove trees and brush from earth embankment extensions and dike.

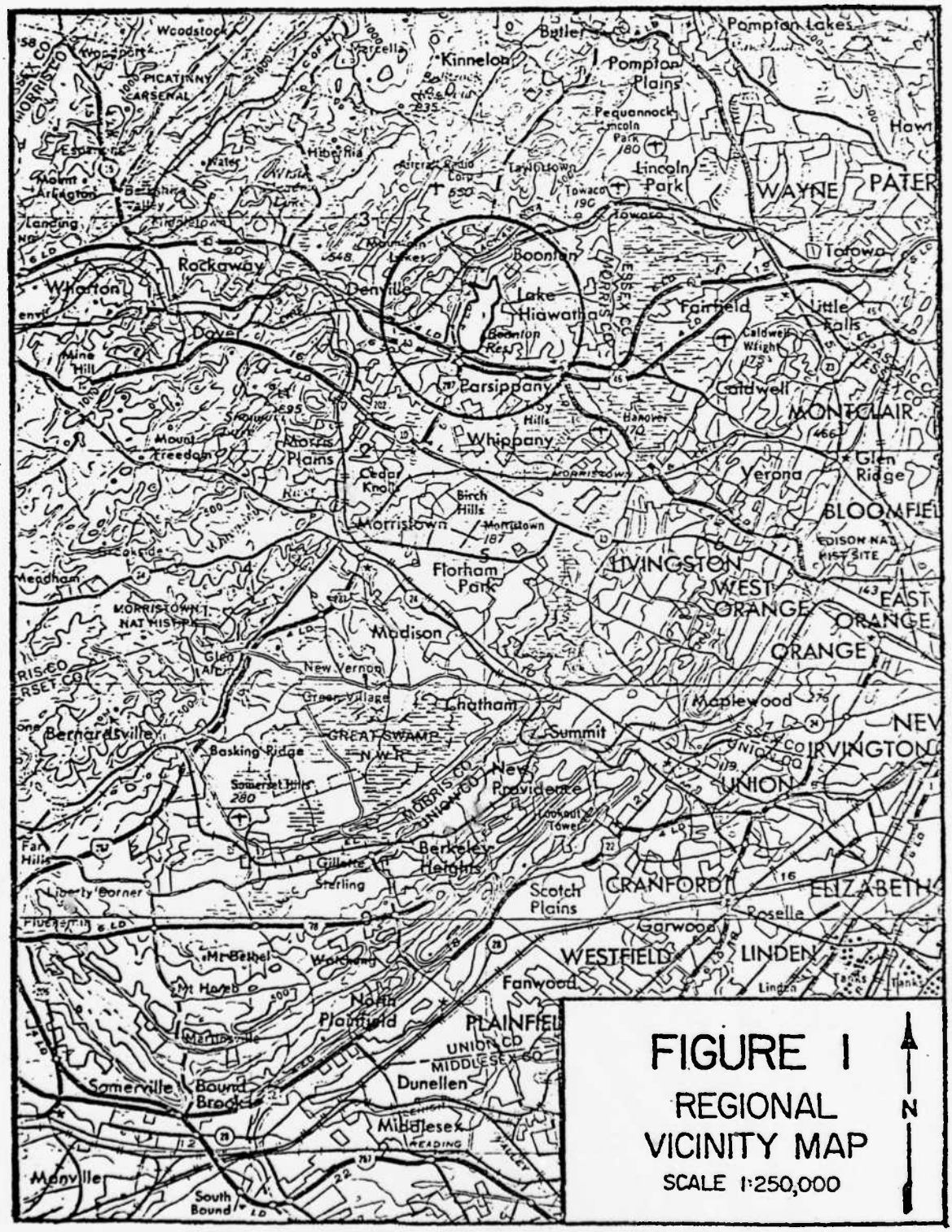
8. Install several piezometers to monitor pore pressures in earth embankments and Parsippany Dike.

9. Initiate a system to monitor seepage that is occurring at the toe of the earth embankment extensions and Parsippany Dike.

10. Clean or replace screens at the intakes and inspect gates to determine condition and repairs required.

11. Provide for automation of bascule gates in order to restore full spillway capacity during high runoff and also allow for maximum storage when desired.

FIGURES


Woodstock
Kinnelon
Butler
Pompton Lakes
Pompton Plains
PICATINNY ARSENAL
Pequannock
Lincoln Park
Hibernia
Wayne
Pater
Towaco
Boonton
Rockaway
Denville
Lake Hiawatha
Fairfield
Little Falls
Whitton
Dover
Mine Hill
Parsippany
Caldwell
Montclair
Mount Freedom
Morris Plains
Whippany
Hanover
Glen Ridge
Verona
Cedar Knolls
Birch Hills
Morristown
Bloomfiel
Edison Nat Hist Site
Meadham
Florham Park
Livingston
West Orange
East Orange
Orange
Morristown Nat Hist Pk
Madison
New Vernon
Glen Arl
Green Village
Chatham
Maplewood
Irvington
Bernardsville
Basking Ridge
Great Swamp N.W.R.
Summit
Union
Somerset Hills
New Providence
Far Hills
Berkeley Heights
Gillette
Stirling
Liberty Corner
Scotch Plains
Cranford
Elizabeth
Roselle
Garwood
Mt Bethel
Warrenville
Westfield
Linden
Fanwood
North Plainfield
Plainfield
Union Co
Middlesex Co
Somerville
Bound Brook
Dunellen
Middlesex
Manville
South Bound
FIGURE 1
REGIONAL
VICINITY MAP
SCALE 1:250,000
N

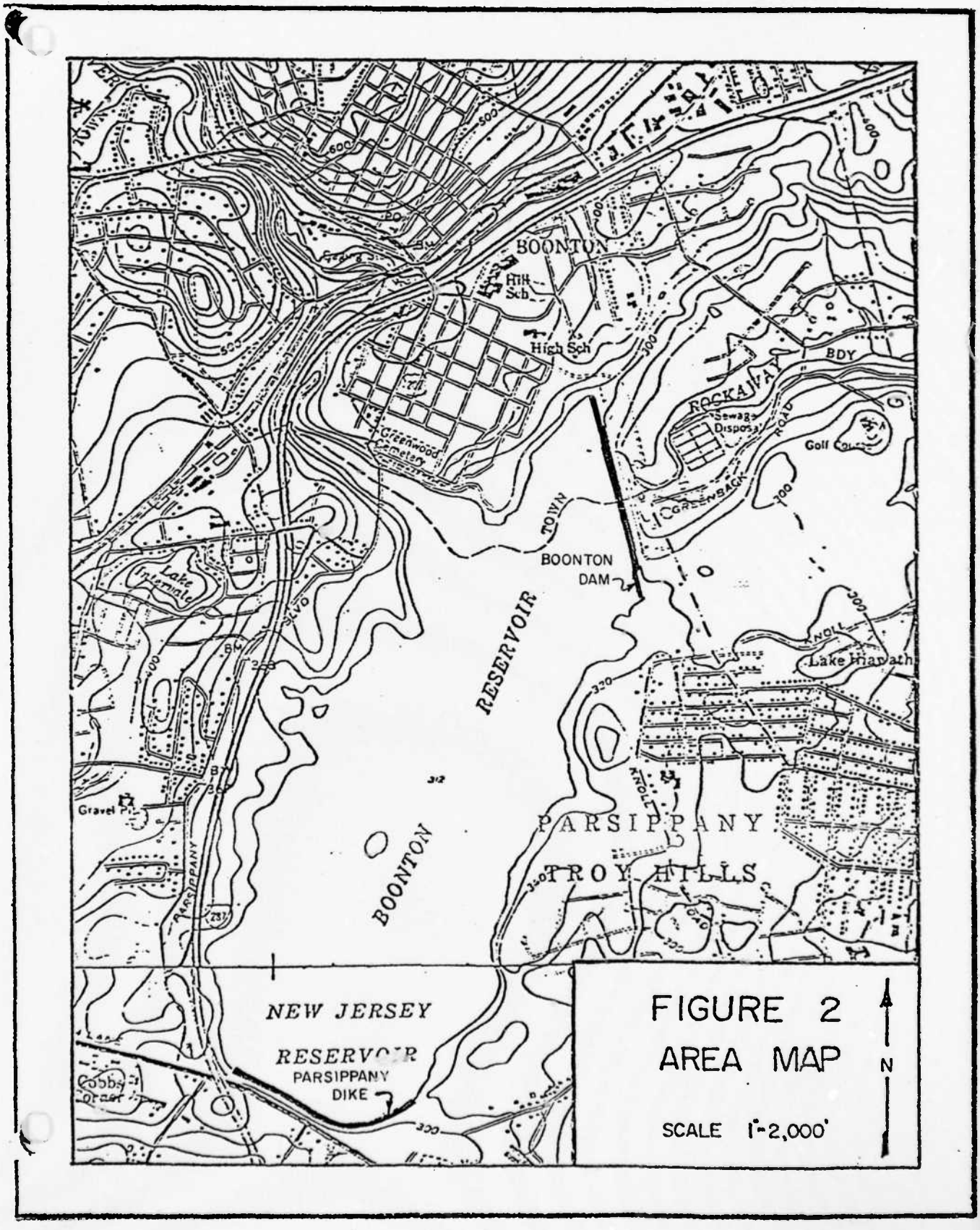
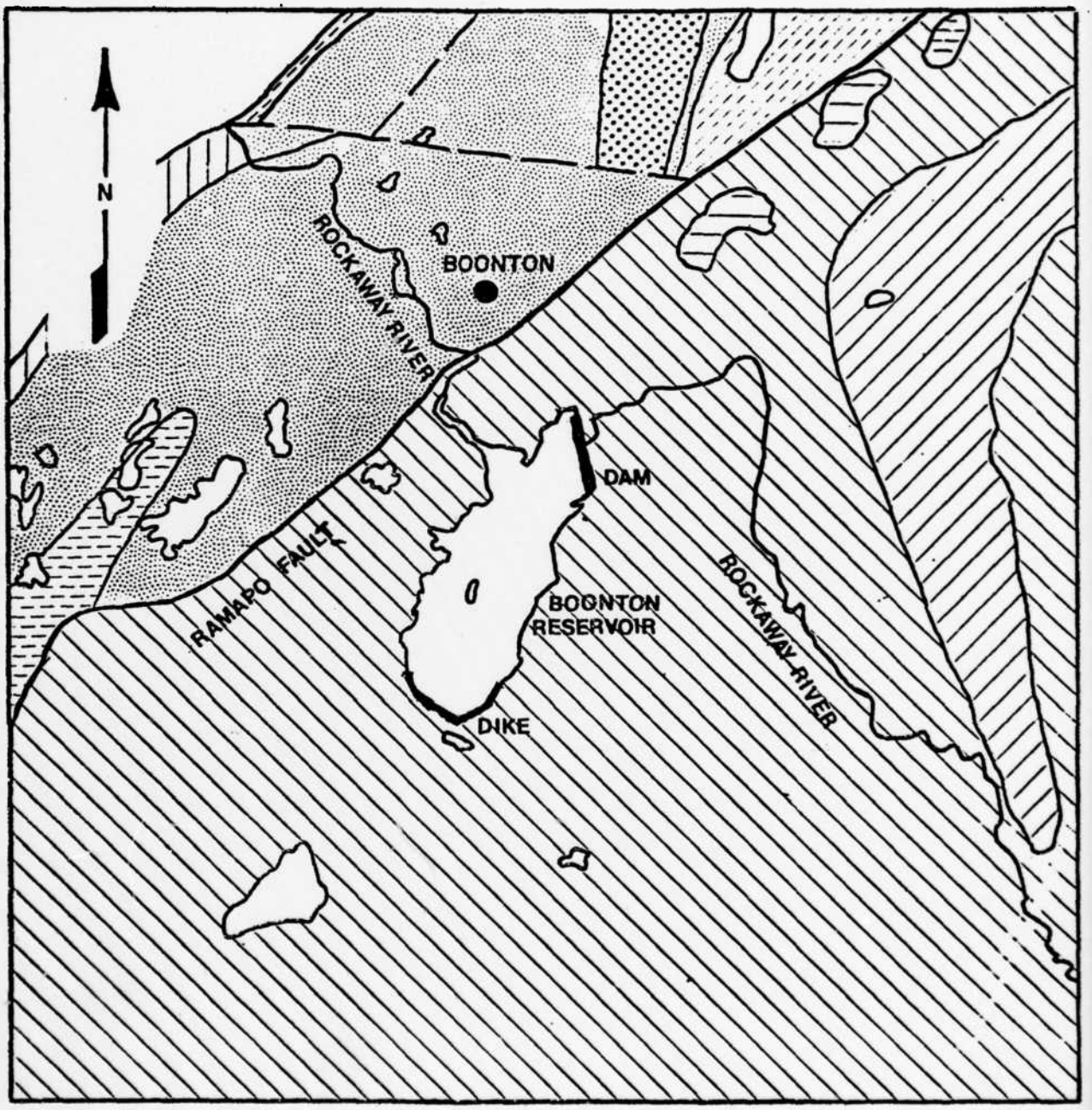


FIGURE 2
AREA MAP

SCALE 1"=2,000'

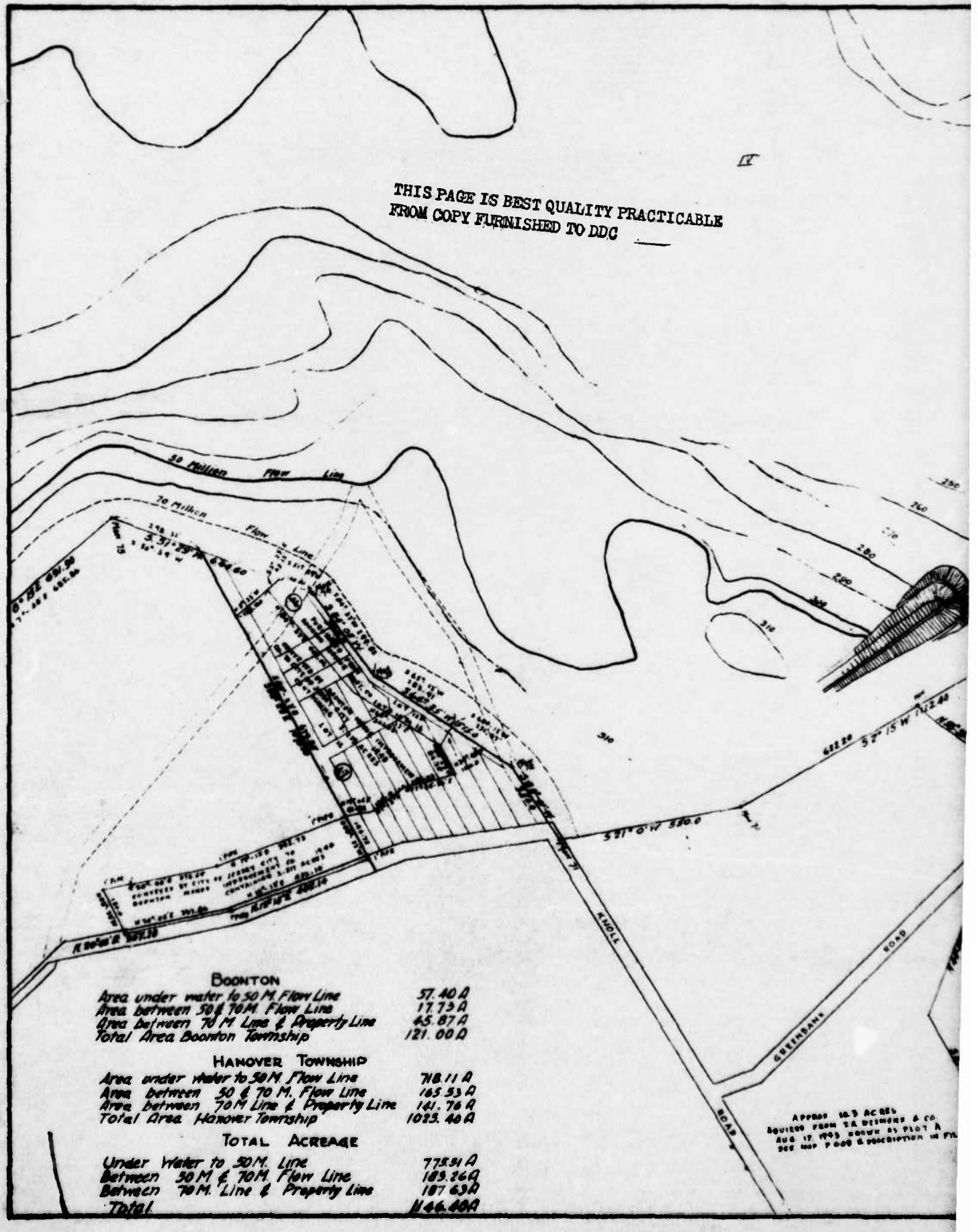


LEGEND

- Trb - Brunswick Formation - shale with sandstone beds
- Trbs - Basalt Flows - fine-grained rock
- Trc - Brunswick Formation - conglomerate beds with quartzite or limestone pebbles
- gpx - Pyroxene Gneiss - coarse-grained rock
- gh - Hornblende Granite & Gneiss - fine and coarse-grained rock
- gd - Granodiorite Gneiss - coarse-grained rock
- hqa - Hypersthene-Quartz-Andesine Gneiss - coarse-grained rock
- am - Amphibolite - coarse-grained rock

FIGURE 3

GEOLOGIC MAP



BOONTON

Area under water to 50 M. Flow Line	57.40 A
Area between 50 & 70 M. Flow Line	17.73 A
Area between 70 M Line & Property Line	45.87 A
Total Area Boonton Township	121.00 A

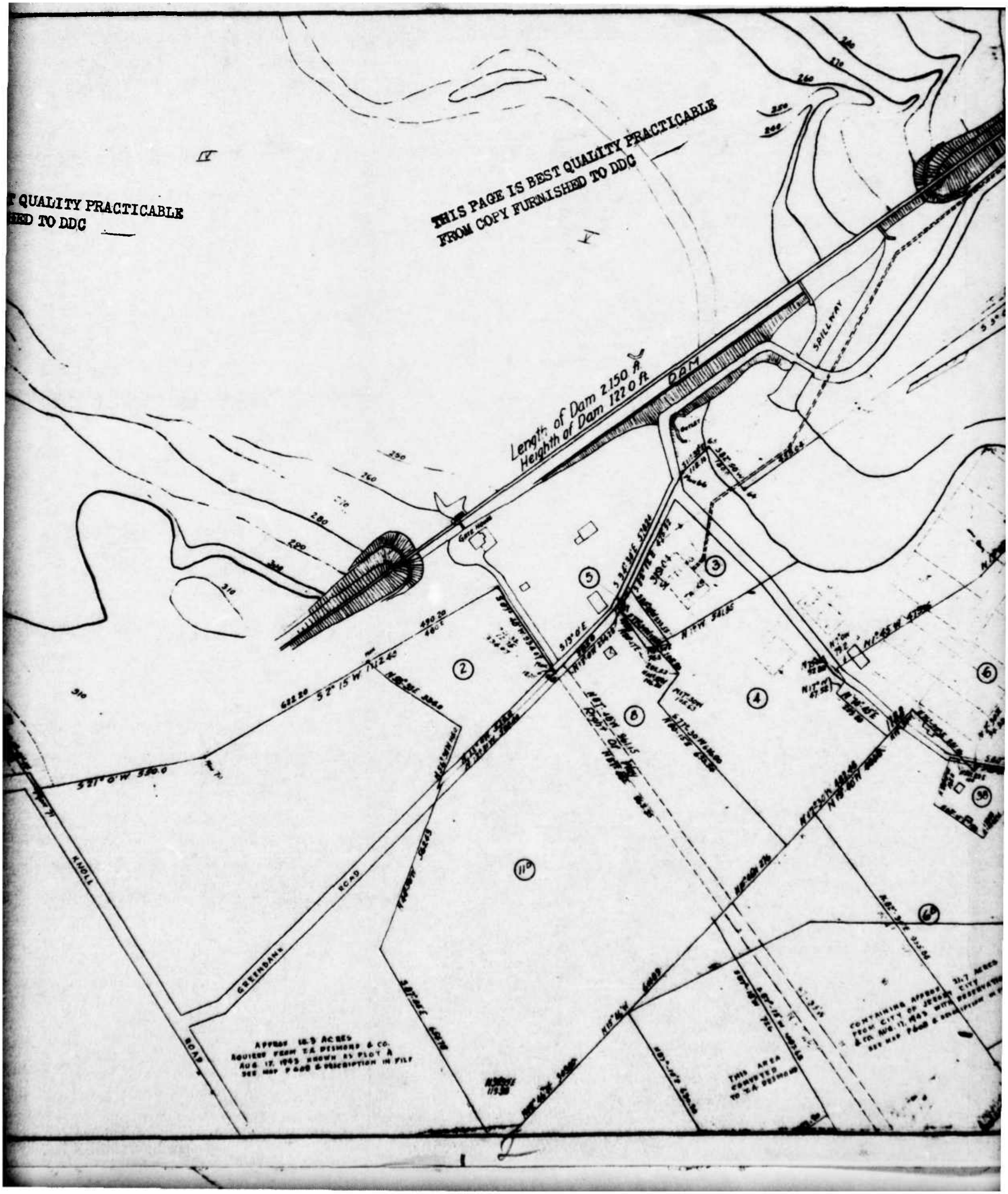
HANOVER TOWNSHIP

Area under water to 50 M. Flow Line	718.11 A
Area between 50 & 70 M. Flow Line	165.53 A
Area between 70 M Line & Property Line	141.76 A
Total Area Hanover Township	1025.40 A

TOTAL ACREAGE

Under Water to 50 M. Line	775.51 A
Between 50 M & 70 M. Flow Line	183.26 A
Between 70 M. Line & Property Line	187.63 A
Total	1146.40 A

APPROX 10.3 ACRES
ACQUIRED FROM E.A. DEMAREST & CO.
AUG 17 1943 SHOWN AS PLOT A
SEE MAP P 606 & DESCRIPTION IN FILE



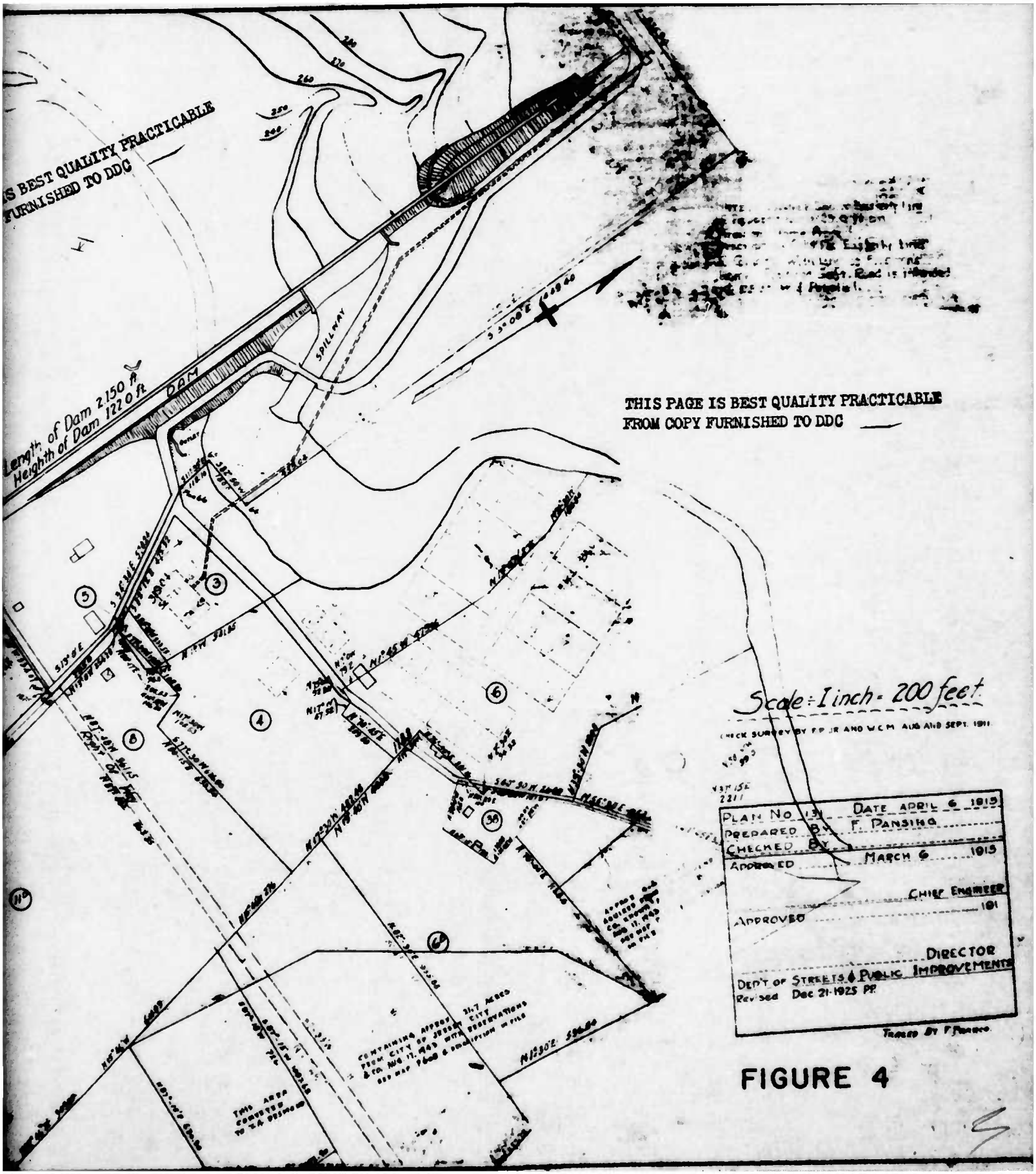
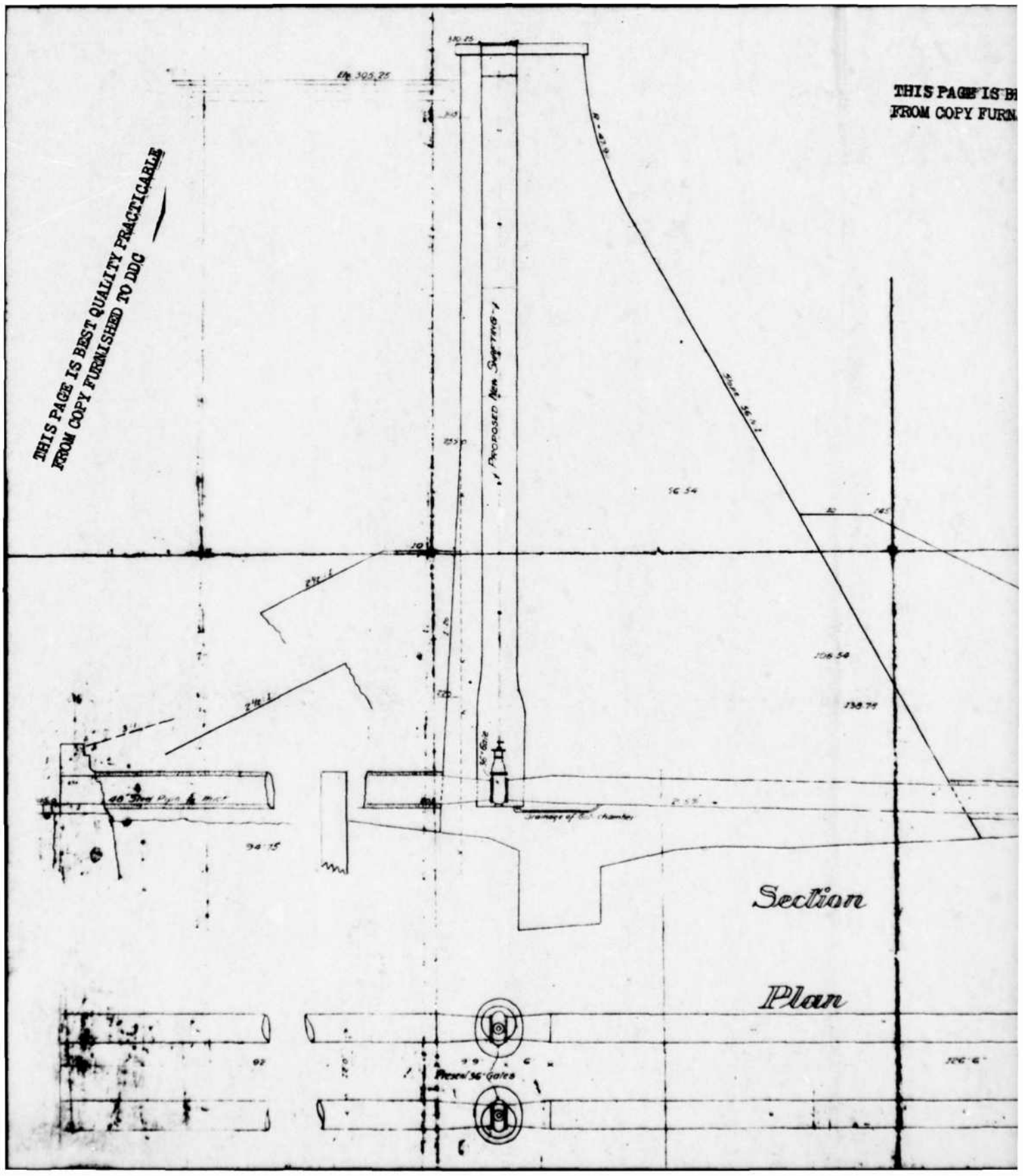


FIGURE 4



SKETCH

showing section through Sluice-way and proposed new 36" Gate at end of same

Scale ⅛"=1ft

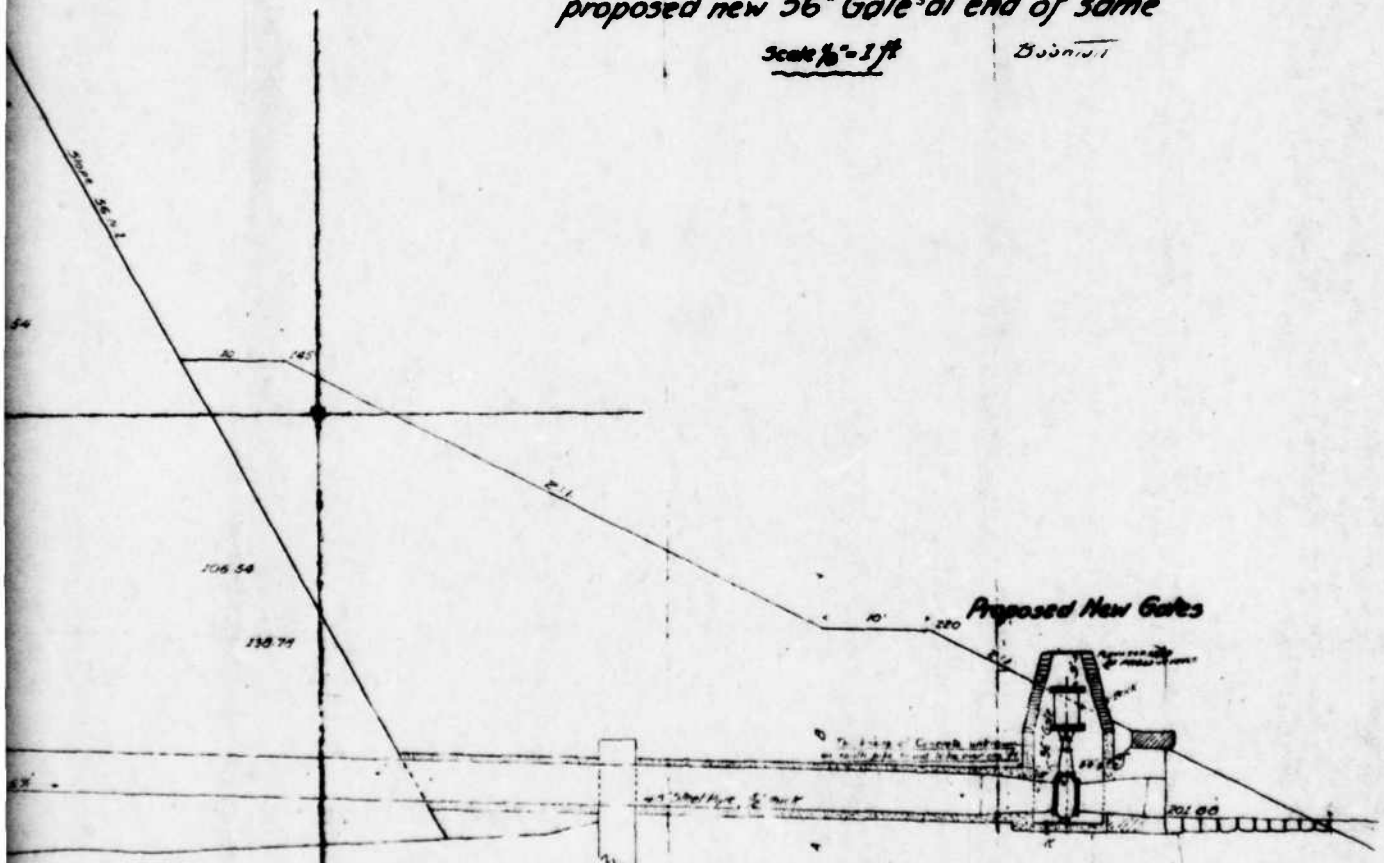
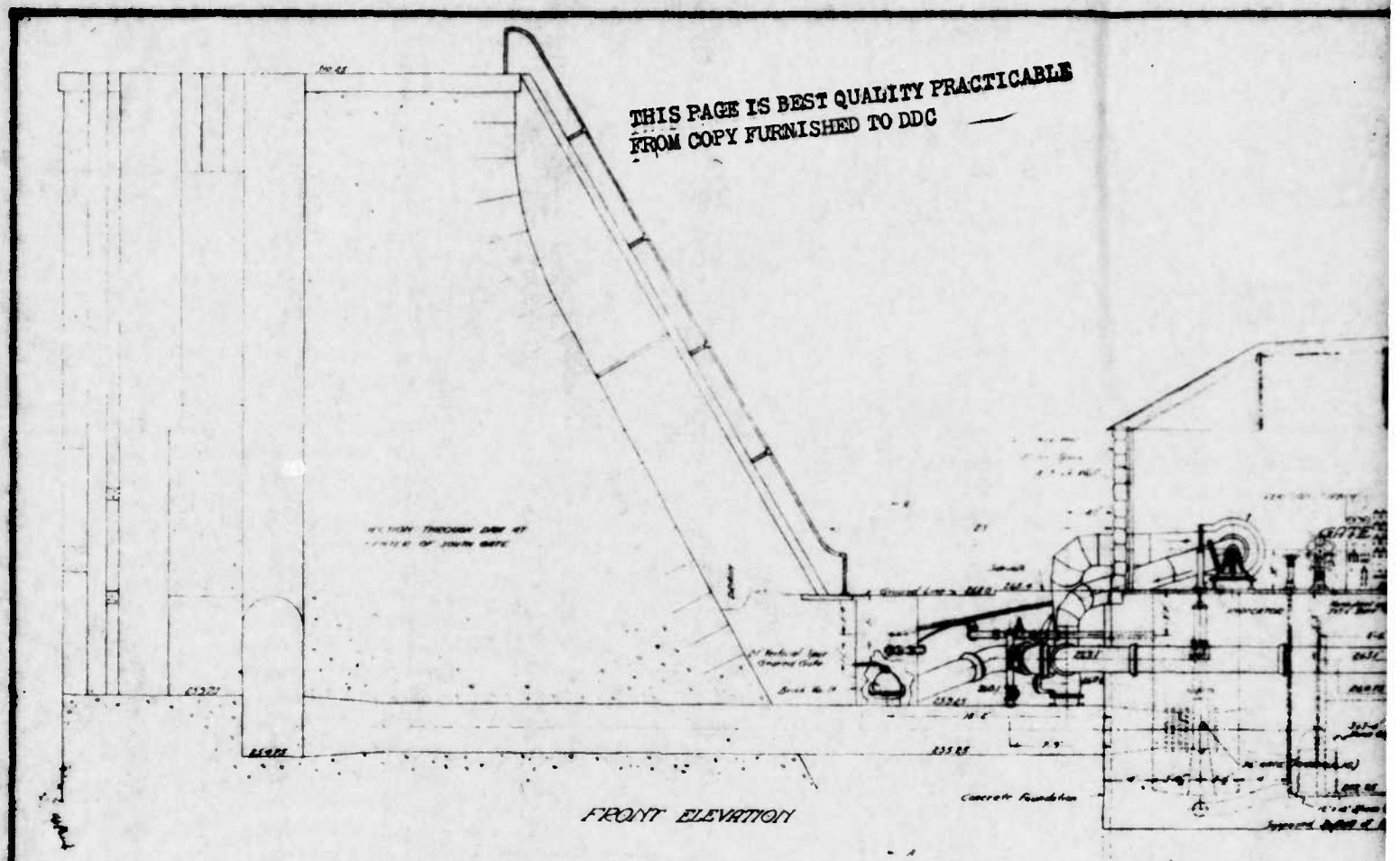
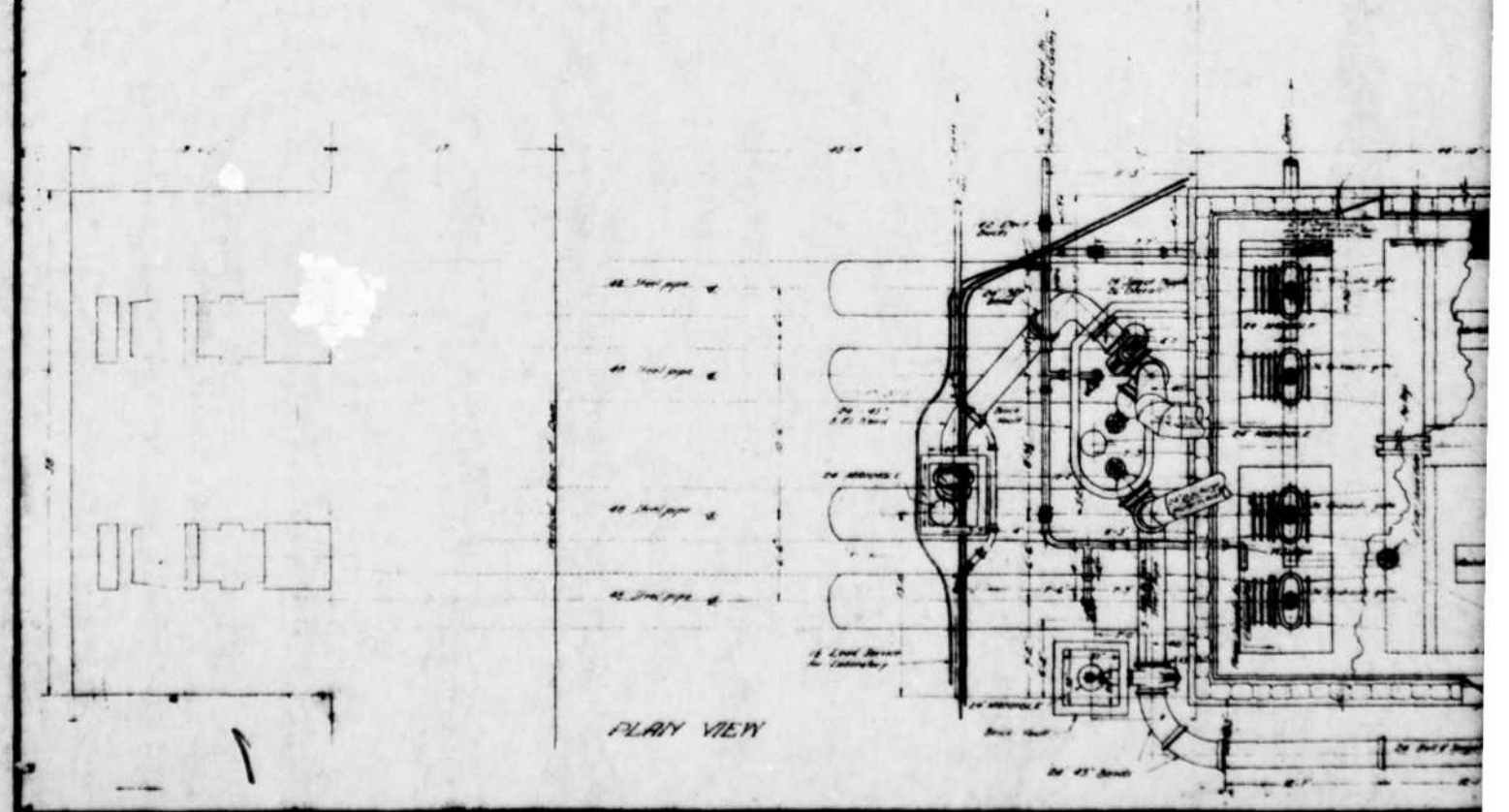


FIGURE 5



FRONT ELEVATION



PLAN VIEW

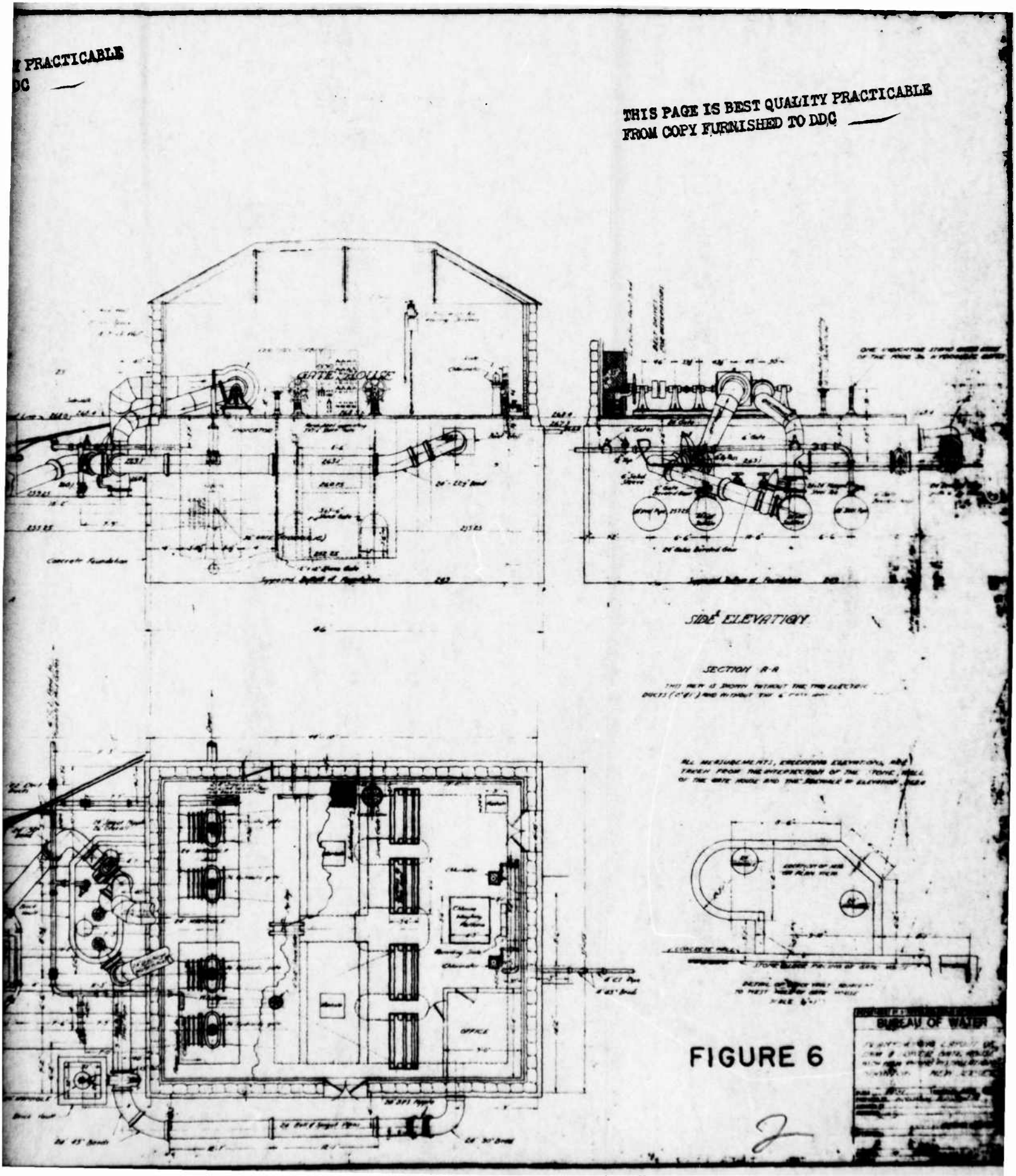
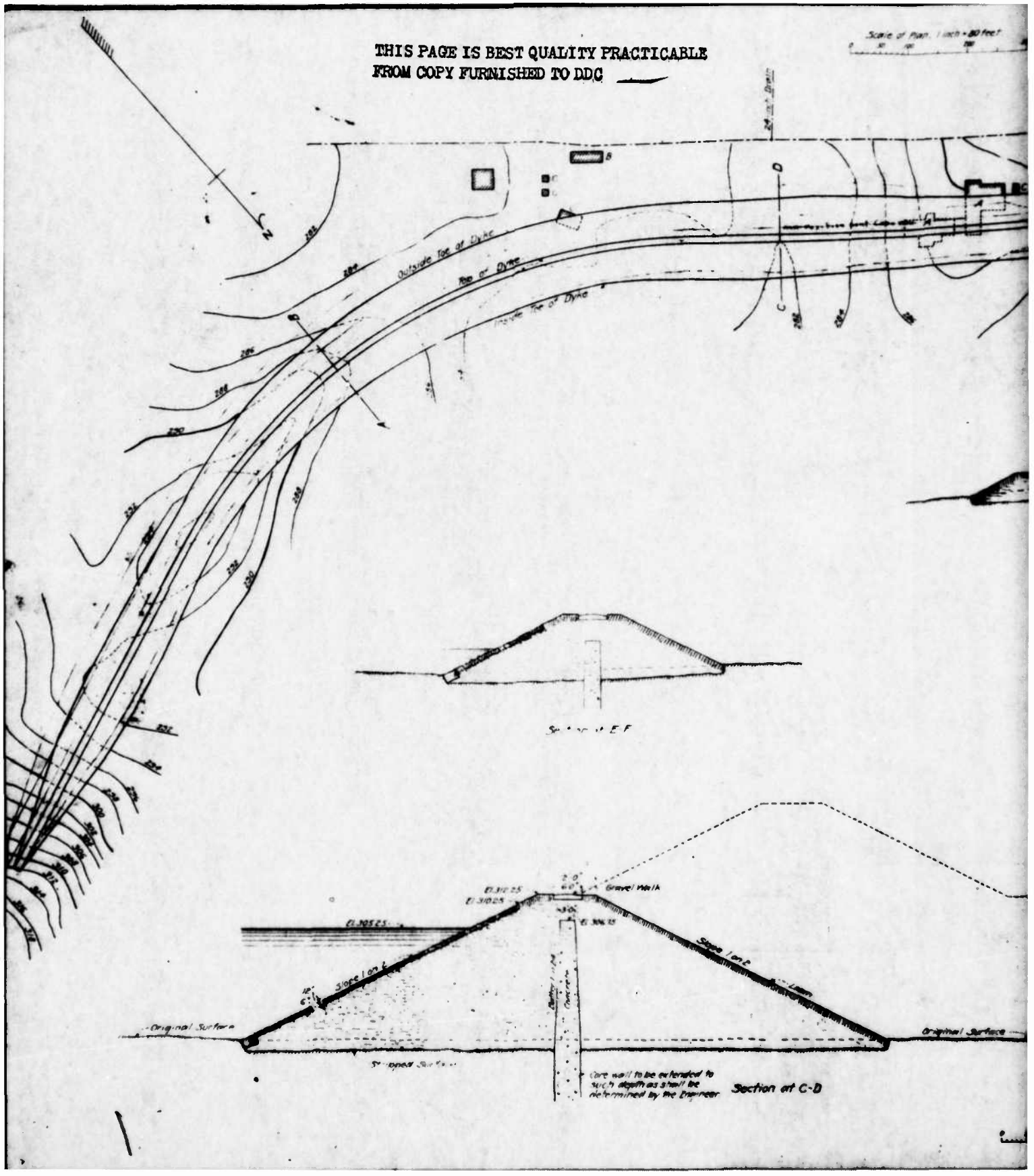
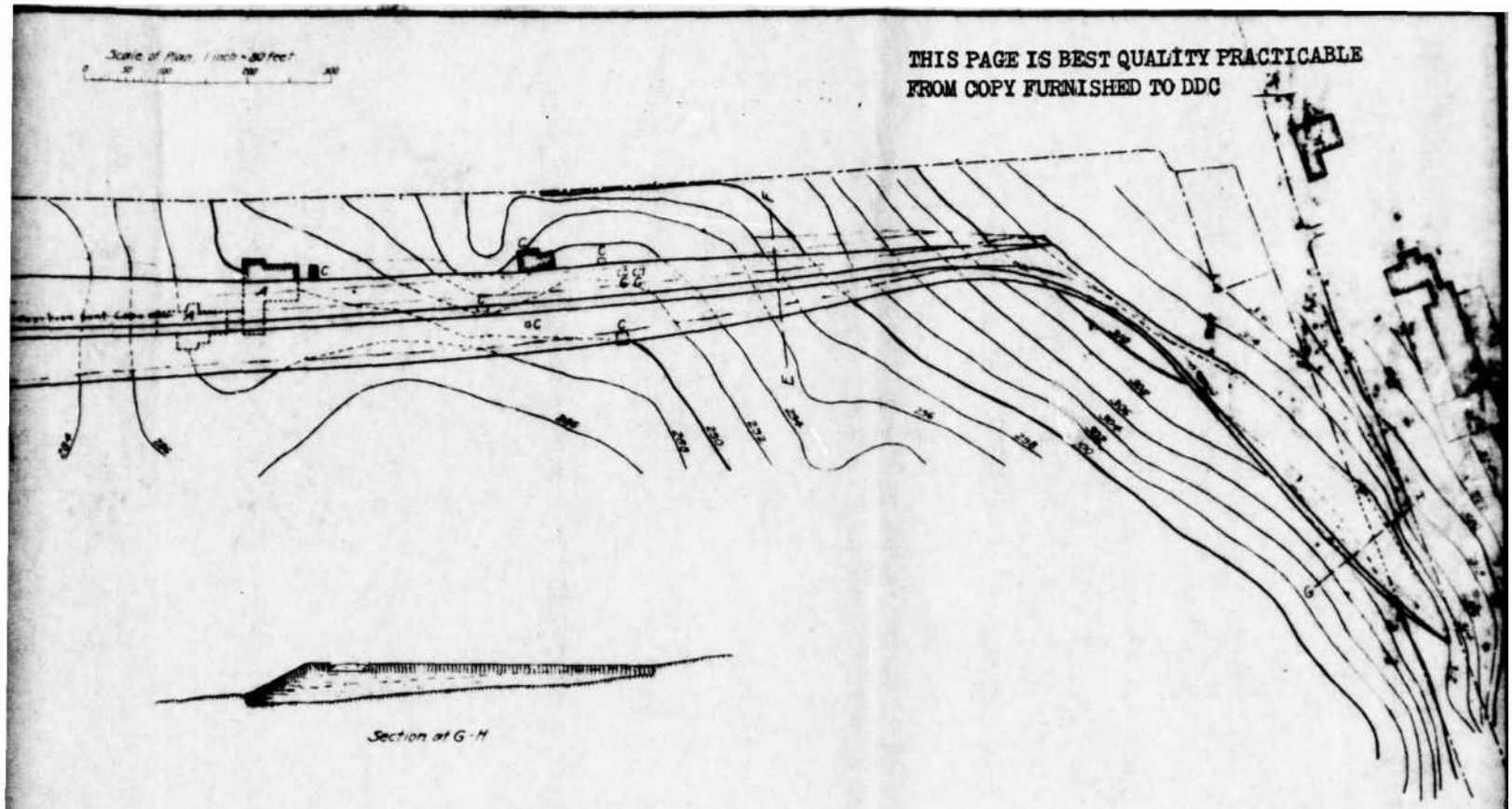


FIGURE 6





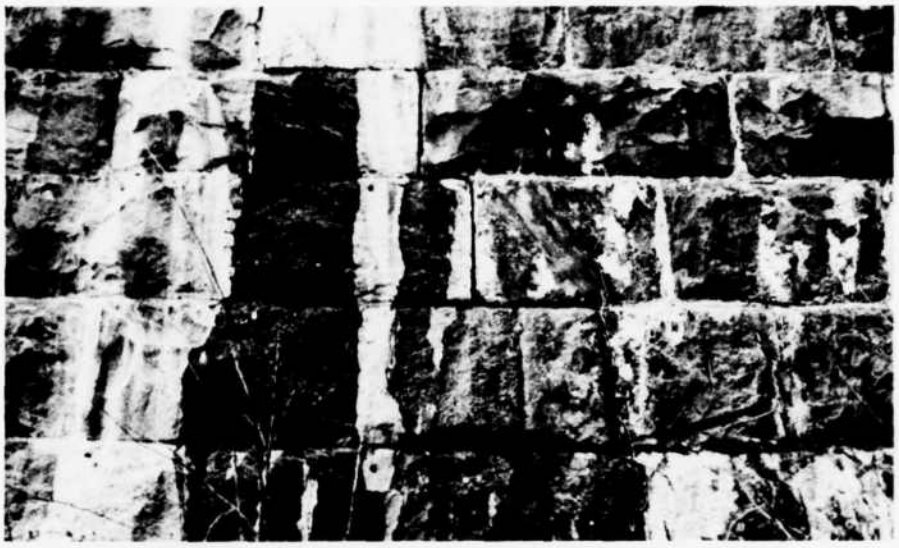
Contract No 5
Jersey City Water Supply Co
Jersey City, N.J.

Parsippany Dike
General Plan & Cross-Sections

Scales as indicated
Aug 1, 1902.

FIGURE 7

PHOTOGRAPHS



CRACK AND SEEPAGE AT NORTH END OF DAM

EMBANKMENT DAMAGE BY BURROWING RODENTS
AT SOUTH END OF DAM

Plate 1

DISLOCATION OF GROUTED RIP RAP SLOPE PROTECTION AT NORTH END OF DAM

FAILURE OF SLOPE PROTECTION AT DIKE ALONG THE SOUTHERN END OF THE RESERVOIR

APPENDIX

FIELD INSPECTION REPORT

Check List
Visual Inspection
Phase 1

Name Dam Boonton Reservoir Dam Parsippany Dike County Morris State New Jersey Coordinators Mr. L. Woscyna New Jersey DEP

Date(s) Inspection 4/14/78 Weather Partly Cloudy Temperature 50°F

Pool Elevation at Time of Inspection About 305.45 M.S.L. Tailwater at Time of Inspection N/A M.S.L.

Inspection Personnel:

Mr. J.J. Williams
Mr. L.H. DeHeer
Mr. R.E. Horvath
Mr. A.J. Depman
Mr. C.A. Schwalbe
Mr. G.C. Elias

Mr. R.E. Horvath Recorder

Accompanied By:

Mr. V. Calvarese - Chief Structural Engineer, U.S. Army Corps of Engineers, Philadelphia District
Mr. C. Brozowski - Supervising Principle Engineer, Jersey City Water Works
Mr. G. Plastoris - Watershed Superintendent, Jersey City Water Works
Mr. L. Woscyna - Civil Engineer, New Jersey Department of Environmental Protection

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SEE PAGE ON LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS	Surface subsidence was noted on the crest of both earth embankment extensions about 50 feet from the ends of the masonry dam. The subsidence extends into the grouted riprap slope protection.	The subsidence is minor in both cases but should be observed at frequent intervals to detect further settlement.
DRAINS	Seepage was located at the toe of the non-overflow masonry dam near the south embankment extension. About 3 inches (2 to 3 gpm) of clear water was present at the time of inspection.	Flow should be monitored to detect any significant variations in flow quality or quantity.
WATER PASSAGES	The spillway surfacing shows no indication of deterioration and appears to be in good condition. Some repair of the grouted joints appears to have been done.	None
FOUNDATION	Not observed	None

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES	The concrete serviceway located on the masonry dam crest is cracked and has deteriorated in several locations. Cracks in the downstream face of the structure were noted in four locations.	Seepage was observed at each surface crack in the downstream face of the dam. Seepage should be visually observed to detect any significant increases in flow quantities.
STRUCTURAL CRACKING	None observed	
VERTICAL AND HORIZONTAL ALIGNMENT	Vertical and horizontal alignment of the masonry dam appeared to be good.	None
MONOLITH JOINTS	Not applicable	
CONSTRUCTION JOINTS	No movement could be detected in the construction joints. Deterioration of joint material was observed at some locations.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None Noted Holes in the earth embankments caused by burrowing rodents were noted in several locations.	Operating personnel are aware of the problem and are actively engaged in eliminating the rodents.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None Noted	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	See riprap failures	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Vertical and horizontal alignment of the crest appeared to be good.	
RIPRAP FAILURES	Failure of the grouted riprap slope protection on the earth embankments was noted in several locations. Some cracking of joints due to settlement was also evident. Failure of the grout surfacing on the earth dike was observed at several locations	Slope protection should be repaired.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No settlement or erosion was noted at either the main dam or Parsippany Dike locations.	
ANY NOTICEABLE SEEPAGE	-Seepage was observed in the toe area at the southern earth embankment extension junction with the masonry dam. Flow was clear and estimated at 2-3 gpm. -Seepage was observed in isolated areas in the toe area of the Parsippany Dike.	Seepage flows should be monitored to detect any changes in flow quantity or quality.
STAFF GAGE AND RECORDER	None Noted.	
DRAINS	None Noted.	

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	The sill appeared to be in good condition. No indication of distress in the masonry was noted.	
APPROACH CHANNEL	Not observed.	
DISCHARGE CHANNEL	The discharge channel is constructed of rock set in place w/grouted joints. No indication of erosion or undue settlement was noted.	Some of the grouted joints appeared to have undergone repair.
BRIDGE AND PIERS	The bridge and piers over the south half of the gated spillway appeared to be in good condition. No indications of deterioration were noted.	
GATES AND OPERATION EQUIPMENT	Gates and operational equipment appear to be in good condition. No equipment was operated during the inspection. *Note: At the time of inspection, the spillway way actively discharging under a head of about 0.2'. The bascule gates were in the lowered position.	The gate controls are being refitted for electrical operators. However, remote activation will not be provided.

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIO
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	A highway bridge is located about 4,000 feet downstream of the dam-site.	
SLOPES	No indications of slope failure were noted.	
APPROXIMATE NO. OF HOMES AND POPULATION	The area immediately downstream of the main dam is sparsely populated. However, the community of Lower Montville is located about 3 miles below the main dam. The area immediately below the Parsippany Dike is commercially developed.	A flood warning system should be implemented.

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	No indication of slope failure was observed.	
SEDIMENTATION	Two 48 inch diameter drain pipes are operated periodically to flush bottom deposits.	

ITEM	REMARKS
MONITORING SYSTEMS	None Noted
MODIFICATIONS	Crest hinged (bascule) gates were installed on the overflow spillway in 1955.
HIGH POOL RECORDS	High pool records dating from 1950 are available.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None Noted
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None Noted
MAINTENANCE OPERATION RECORDS	None Noted

ITEM	REMARKS
DESIGN REPORTS	None Noted
GEOLOGY REPORTS	None Noted
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None Noted
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None Noted
POST-CONSTRUCTION SURVEYS OF DAM	A general plan of the dam and reservoir area was prepared in 1915 and was available for review.
BORROW SOURCES.	None Noted

A11

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None Noted	
OBSERVATION WELLS	None Noted	
WEIRS	None Noted	
PIEZOMETERS	None Noted	
OTHER	A water surface elevation indicator is located in the upper gate house.	The indicator system is old but appears to be operational.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Not available
REGIONAL VICINITY MAP	Not available
CONSTRUCTION HISTORY	A brief description was furnished verbally by representatives of the Jersey City Water Works.
TYPICAL SECTIONS OF DAM	Typical sections of the masonry dam (non-overflow section) and dike were made available for review.
HYDROLOGIC/HYDRAULIC DATA	The reservoir stage-storage table (limited to the elevations within the operational range of the bascule gates) was provided.
OUTLETS - PLAN - DETAILS -CONSTRAINTS -DISCHARGE RATINGS	Plans and details of the reservoir sluice gates and water supply gates were furnished. A minimum discharge of 7 cfs must be maintained for augmentation of downstream water supply. The spillway rating table was provided.
RAINFALL/RESERVOIR RECORDS	Rainfall/reservoir records are available and a sample was provided for review.

*All information described herein was furnished by the J.C.W.W.

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	Not available for review.
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	Crest hinged (bascule) gates are located on the overflow spillway. They are operated between the raised and lowered positions by a manually controlled hydraulic system.

HYDROLOGIC AND HYDRAULIC CALCULATIONS

O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BOONTON RESERVOIR DAM	1	REH	6/13/78	1800.001.195

PROBABLE MAXIMUM FLOOD CALCULATIONS

DRAINAGE AREA = 119 sq miles

PMP - 6 Hour Duration - 10 sq miles
= 26" Zone 6

Basin size reduction = 13%

Depth Area Duration (use 6 hr duration) = 78%

Adjusted PMP = 17.6"

① Ref: Hydrometeorological Report # 33

② EM 1110-2-1405 dtd 8/31/52

③ Design of Small Dam

④ USGS Quad Sheet

Time (Hrs)	% 6 Hr PMP	Σ 24 Hr PMP	INC PMP	
2	65	11.4	11.4	0-6 hr - 78%
4	85	15.0	3.6	0-12 hr - 85%
6	100	17.6	2.6	0-24 hr - 94%
8	103	18.1	.5	
10	106	18.7	.6	
12	109	19.2	.5	
14	111	19.5	.3	
16	113	19.9	.4	
18	115	20.2	.3	
20	117	20.6	.4	
22	119	20.9	.3	
24	121	21.3	.4	

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BOONTON RESERVOIR DAM	2	REH	6/15/78	1800 xx1 - 105

	Rainfall			Run-off	
Time (Hrs)	%	Σ	INCr	Σ	INCr
2	2	.4	.4	0	0
4	2	.7	.3	0	0
6	2	1.1	.4	0	0
8	3	1.6	.5	.1	.1
10	3	2.1	.5	.3	.2
12	3	2.6	.5	.5	.2
14	15	5.3	2.7	2.3	1.8
16	65	16.7	11.4	12.5	10.2
18	20	20.2	3.5	15.8	3.5
20	2	20.6	.4	16.2	.4
22	2	20.9	.3	16.5	.3
24	2	21.3	.4	16.9	.4

Increments are ranked in the order 4.2.1.3 in accordance with EM110-2-163 (Draft)

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
Boonton Reservoir Dam	3	REH	6/15/78	1000.001.195

SNYDER'S PARAMETER'S (Provided by U.S Army Corps of Engr, Phil Dist.)

$C_t = 2.90$

$640\,C_p = 282$

$L = 40$ MILES (estimated from quad sheets)

$L_{CA} = 20$ MILES (estimated from quad sheets)

$T_p = C_t (L L_{CA})^{0.3} = 21.5$

$C_p = .44$

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
Boonton Reservoir Dam	4	REH	6/15/78	12x0001 19

Stage - Discharge Spillway Elev = 305.25

Elev (ft)	Water Supply 92 cfs (avg)	$Q=300(3.33)H^{3/2}$ Spillway Release (cfs)	(overtopping) $Q=3200(3.33)H^{3/2}$ (cfs)	Sluice Gates 2-48" Φ cfs	TOTAL (cfs)
305.25	93	0		1040	1133
306.25		999		1046	2138
307.25		2826		1053	3972
308.25		5191		1058	6342
309.25		7992		1063	9148
310.25		11169	0	1068	12330
311.25		14682	9600	1076	25451
312.25		18502	27153	1080	46828
313.25		22605	49983	1080	73667
314.25	↓	26973	76800	1091	104957

See Sheet A25
for development of
Sluice Gate Discharge

- Avg water supply quantity was provided by JCWW
- Spillway and overtopping discharges were developed from information furnished by JCWW and generalized equations.

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BOONTON RESERVOIR DAM	5	REH	6/18/78	1800.001 135

STAGE - DISCHARGE

SPILLWAY Elev 307.25

Elev (Ft)	Water Supply 93 c.f. (ava)	Spillway Release - cfs	Q=3.2w(2) H^3/2 cfs	Sluice Gates 2-48"ϕ - cfs	TOTAL - cfs
307.25	93	0		1053	1146
308.25		999		1058	2150
309.25		2826		1063	3982
310.25		5191	0	1068	6352
311.25		7992	9600	1076	18761
312.25		11169	27153	1080	39495
313.25		14682	49976	1086	65744
314.25		18502	76800	1091	96486

O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BUCKTON RESERVOIR DAM	6	REL	6/18/78	1900.00 . 1

Stage - Storage Assume 867 Ac Ft/Ft relationship

Stage	Storage (Ac-Ft)		Stage	Storage (Ac-Ft)
Crest @ 305.25	0	Crest @	307.25	0
306.25	867		308.25	867
307.25	1734		309.25	1734
308.25	2601		310.25	2601
309.25	3468		311.25	3468
310.25	4335		312.25	4335
311.25	5202		313.25	5202
312.25	6069		314.25	6069
313.25	6936			
314.25	7803			

Stage - Storage relationship was developed from information furnished by J.C.W.W.

JUSTIN & COURTNEY, INC.
Division of O'Brien & Gere Engineers, Inc.
PHILADELPHIA, PA

SHEET NO. 7 OF _____

DATE 4/21/78

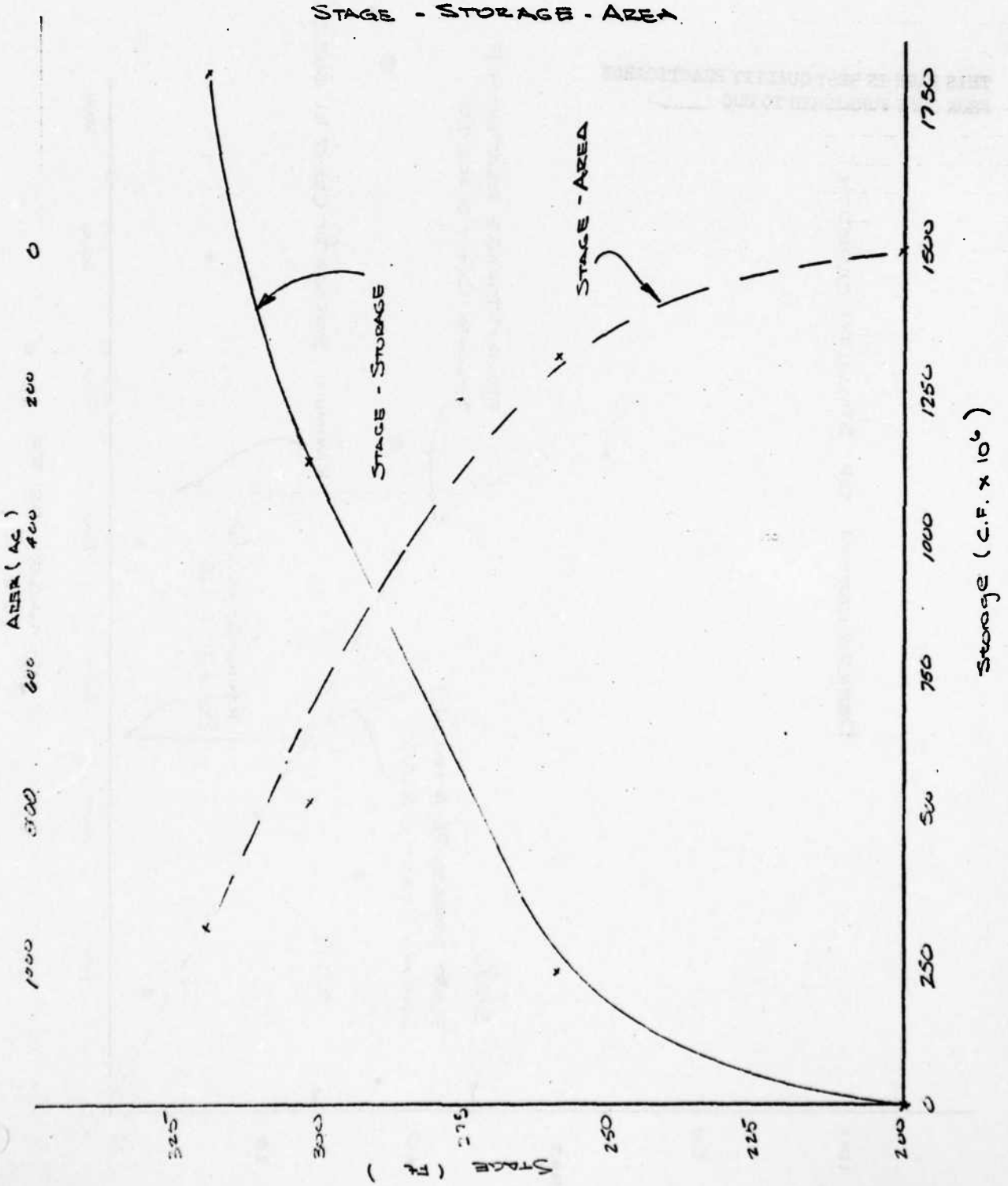
NAME OF CLIENT USACE

COMP. BY PEH

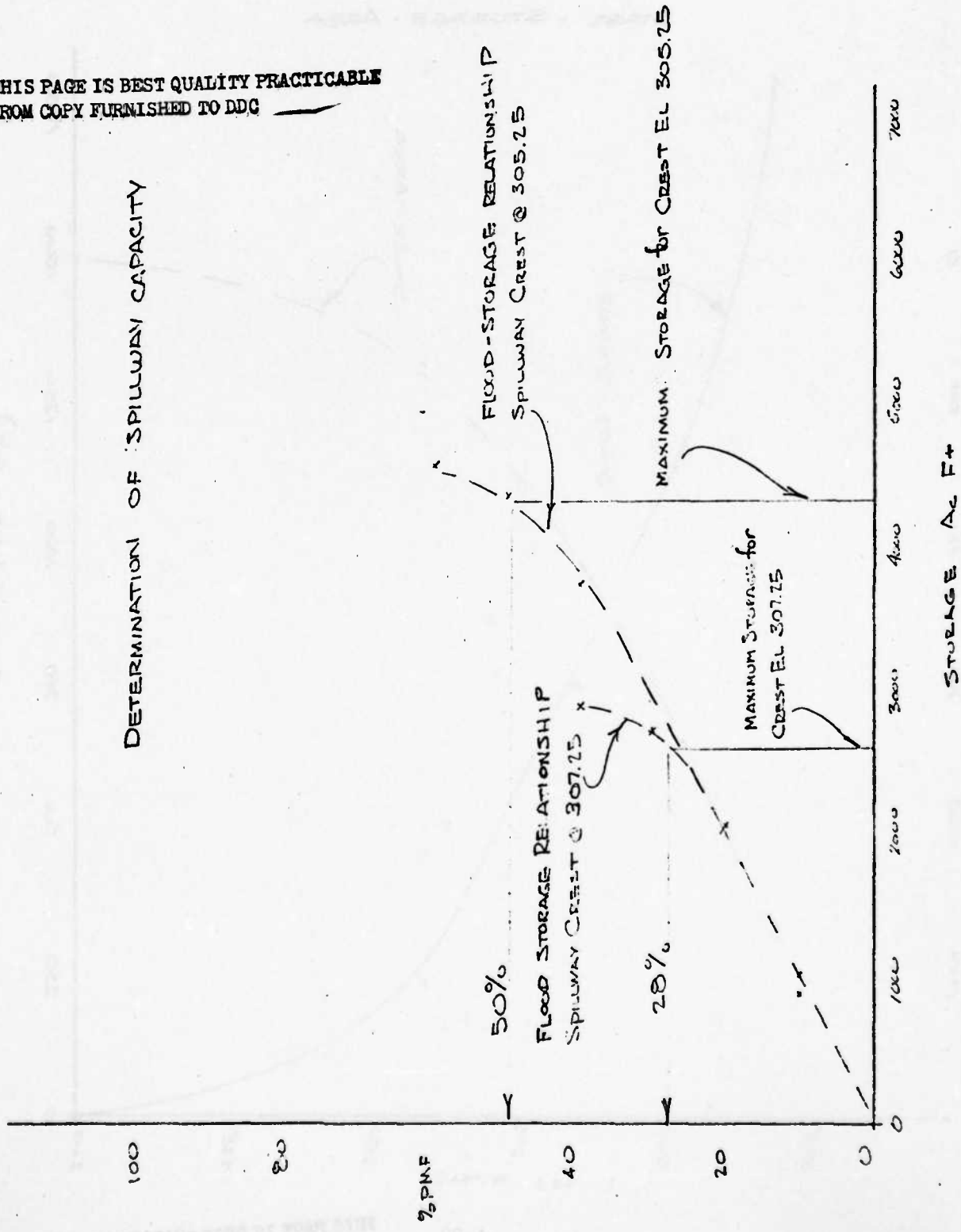
PROJECT BOONTON RESERVOIR DAM

CHECKED BY _____

STAGE - STORAGE - AREA



DETERMINATION OF SPILLWAY CAPACITY



O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO.
Boonton Reservoir Dam	9	REH	6/20/78	1800.001

PMF Summary (See HEC-1 Printout)

Crest Elev	Flood Crest El.	Max Discharge (cfs)	Duration of Overtopping (h
305.25	311.3	26883	40
307.25	311.7	26798	66

Spillway Capacity,

Crest El @ 305.25 - 50 % PMF

Crest El @ 307.25 - 28 % PMF

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BOONTON RESERVOIR DAM	10	REH	5/1/78	1800.001 05

RESERVOIR DRAWDOWN ANALYSIS

2 - 48" DIA STEEL PIPES LENGTH = 233'

Assume OUTLET CONTROL - pipe flowing full - $Q = AV$

$$H = \frac{V^2}{2g}\left(1 + K_e + K_{CONTR} + K_{VALVE} + K_{EXP} + \frac{29n^2L}{r^{1.33}}\right)$$

From KING & BRATER

$K_e = .5$ (Sq corner ent flush with wall)

2-36 VALVES:

K_{CONTR}	$(d_2/d_1 = \frac{48}{36} = 1.33)$	$\approx .14$	$\times 2 = .28$
K_{VALVE}	(ASSUME VOLVE IS OPEN)	$\approx .10$	$\times 2 = .20$
K_{EXP}	$(d_2/d_1 = 1.33)$	$\approx .16$	$\times 2 = .32$
n		$\approx .02$	

$$H = \frac{V^2}{2g}\left(1 + 1.3 + \frac{2.7}{2.5}\right) = 3.38\,\frac{V^2}{2g}$$

$$V = \sqrt{19\,H}$$

Begin drawdown at 303, assume Water Surface Elevation at discharge ≈ 215

O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BOONTON RESERVOIR DAM	11	REH	5/1/78	1800.001 135

WATER SURFACE EL (Ft)	HEAD (Ft)	VEL (FPS)	DISCHARGE (CFS)	DISCHARGE CFS
305	90	41	1030	
295	80	39	980	968
285	70	36	905	
275	60	34	855	842
265	50	31	779	
255	40	28	704	691
245	30	24	603	
235	20	19	477	301
225	10	14	351	
215	0	0	0	

Storage @ Elev 215 ≈ 0 Ac Ft

Storage @ Elev 305 ≈ 25,770 Ac Ft

Assume linear relationship

$\frac{\Delta \text{ Stor}}{\Delta \text{ Elev}} \approx 286$ Ac Ft/Ft

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BOONTON RESERVOIR DAM	12	REH	5/1/78	1500 001 10E

EL	STORAGE (Ac Ft)	INCR. STORAGE Ac Ft	INCR. STORAGE C.F	DISCHARGE CFS	TIME HRS
305	25,770				
		5,750	250×10^6	968	72
285	20,020				
		5,720	249×10^6	842	82
265	14,300				
		5,720	249×10^6	691	100
245	8,580				
		8,580	374×10^6	301	345
215	0				
					599 Hrs
					≈ 25 days

CALCULATIONS INDICATE A MINIMUM DRAWDOWN TIME OF 25 DAYS TO DRAIN THE RESERVOIR BASED ON THE ASSUMPTIONS STATED. HOWEVER, THIS TIME FOR DRAWDOWN IS NOT REALISTIC DUE TO THE DAMAGE THAT WOULD BE CAUSED DOWNSTREAM. SOME CONSTRAINT WOULD BE REQUIRED TO INSURE SAFE DISCHARGES.

HEC-I VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01

PMF ROUTING 305.25 - Spillway Crest El.
ROONTON DAM + PARSIPPANY DIKE
O'BRIEN + GERE - JUSTIN + COURTNEY DIV

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
48	2	0	1	0	0	0	0	2	0

JOPER	NWI
5	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 9 LRTIO= 1

RTIOS= .10 .20 .30 .40 .50 .60 .70 .80 1.00

SUB-AREA RUNOFF COMPUTATION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	1	119.00	0.00	0.00	0.00	0.000	0	0	0

PRECIP DATA

NP	STORM	DAJ	DAK
12	0.00	0.00	0.00

PRECIP PATTERN

0.00 0.00 0.00 .10 .20 .20 1.80 10.20 3.50 .40 .30 .40

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00

UNIT HYDROGRAPH DATA
TP= 21.50 CP= .44 NTA= 0

RECESSION DATA
STRTQ= 0.00 QRCSN= 0.00 RTIOR= 1.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=11.19 AND R=17.61 INTERVALS

UNIT HYDROGRAPH 100 END-OF-PERIOD ORDINATES, LAG= 21.56 HOURS, CP= .44 VOL= 1.00

40.	151.	311.	500.	712.	939.	1156.	1337.	1477.	1571.
1611.	1574.	1491.	1408.	1331.	1257.	1188.	1122.	1060.	1002.
946.	894.	845.	798.	754.	712.	673.	636.	601.	568.
536.	507.	479.	452.	427.	404.	381.	360.	340.	322.
304.	287.	271.	256.	242.	229.	216.	204.	193.	182.
172.	163.	154.	145.	137.	130.	122.	116.	109.	103.
98.	92.	87.	82.	78.	73.	69.	66.	62.	59.
55.	52.	49.	47.	44.	42.	39.	37.	35.	33.
31.	30.	28.	26.	25.	24.	22.	21.	20.	19.
18.	17.	16.	16.	14.	13.	13.	12.	11.	11.

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
1	2 0	0.00	0.00	0.
1	4 0	0.00	0.00	0.
1	6 0	0.00	0.00	0.
1	8 0	.10	.10	4.
1	10 0	.20	.20	23.
1	12 0	.20	.20	69.
1	14 0	1.80	1.80	214.
1	16 0	10.20	10.20	913.
1	18 0	3.50	3.50	2575.
1	20 0	.40	.40	5058.
1	22 0	.30	.30	8097.
2	0 0	.40	.40	11537.
2	2 0	0.00	0.00	15222.
2	4 0	0.00	0.00	18808.
2	6 0	0.00	0.00	21922.
2	8 0	0.00	0.00	24385.
2	10 0	0.00	0.00	26106.
2	12 0	0.00	0.00	26932.
2	14 0	0.00	0.00	26658.
2	16 0	0.00	0.00	25592.
2	18 0	0.00	0.00	24320.
2	20 0	0.00	0.00	23045.
2	22 0	0.00	0.00	21794.
3	0 0	0.00	0.00	20592.
3	2 0	0.00	0.00	19455.
3	4 0	0.00	0.00	18381.
3	6 0	0.00	0.00	17366.
3	8 0	0.00	0.00	16408.
3	10 0	0.00	0.00	15502.
3	12 0	0.00	0.00	14646.
3	14 0	0.00	0.00	13837.
3	16 0	0.00	0.00	13073.
3	18 0	0.00	0.00	12352.
3	20 0	0.00	0.00	11670.
3	22 0	0.00	0.00	11025.
4	0 0	0.00	0.00	10417.
4	2 0	0.00	0.00	9841.
4	4 0	0.00	0.00	9298.
4	6 0	0.00	0.00	8785.
4	8 0	0.00	0.00	8300.
4	10 0	0.00	0.00	7842.
4	12 0	0.00	0.00	7409.
4	14 0	0.00	0.00	7000.
4	16 0	0.00	0.00	6613.
4	18 0	0.00	0.00	6248.
4	20 0	0.00	0.00	5903.
4	22 0	0.00	0.00	5577.
5	0 0	0.00	0.00	5269.
	SUM	17.10	17.10	566083.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	26932.	26566.	23301.	15177.	566086.
INCHES		2.08	7.29	14.24	14.25
AC-FT		13180.	46241.	90358.	93616.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

0.	0.	0.	0.	2.	7.	21.	91.	258.	586.
810.	1154.	1522.	1881.	2192.	2438.	2611.	2693.	2666.	2559.
2432.	2304.	2179.	2059.	1946.	1838.	1737.	1641.	1550.	1466.
1384.	1307.	1235.	1167.	1103.	1042.	984.	930.	878.	838.
784.	741.	700.	661.	625.	590.	558.	527.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2693.	2657.	2330.	1518.	56609.
INCHES		.21	.73	1.42	1.48
AC-FT		1318.	4624.	9036.	9362.

3

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

0.	0.	0.	1.	5.	14.	43.	183.	515.	1012.
1619.	2307.	3044.	3762.	4384.	4877.	5221.	5386.	5332.	5118.
4864.	4609.	4359.	4118.	3891.	3676.	3473.	3282.	3100.	2929.
2767.	2615.	2470.	2334.	2205.	2083.	1968.	1860.	1757.	1660.
1568.	1482.	1400.	1323.	1250.	1181.	1115.	1054.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5386.	5313.	4660.	3035.	113217.
INCHES		.42	1.46	2.85	2.95
AC-FT		2636.	9248.	18072.	18723.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

0.	0.	0.	1.	7.	21.	64.	274.	773.	1518.
2429.	3461.	4566.	5643.	6577.	7315.	7832.	8080.	7997.	7678.
7296.	6913.	6538.	6178.	5837.	5514.	5210.	4922.	4651.	4394.
4151.	3922.	3705.	3501.	3308.	3125.	2952.	2789.	2635.	2490.
2352.	2223.	2100.	1984.	1874.	1771.	1673.	1581.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	8080.	7970.	6990.	4553.	169826.
INCHES		.62	2.19	4.27	4.43
AC-FT		3954.	13872.	27107.	28085.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

0.	0.	0.	2.	9.	28.	86.	365.	1030.	2023.
3239.	4615.	6089.	7523.	8769.	9754.	10442.	10773.	10663.	10237.
9728.	9218.	8718.	8237.	7782.	7353.	6947.	6563.	6201.	5858.
5535.	5229.	4941.	4668.	4410.	4167.	3937.	3719.	3514.	3320.
3137.	2963.	2800.	2645.	2499.	2361.	2231.	2108.		

A-30

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10773.	10626.	9320.	6071.	226434.
INCHES		.83	2.91	5.69	5.90
AC-FT		5272.	18496.	36143.	37446.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 5

0.	0.	0.	2.	12.	35.	107.	457.	1288.	2529.
4049.	5768.	7611.	9404.	10961.	12192.	13053.	13466.	13329.	12796.
12160.	11522.	10897.	10296.	9720.	9191.	8683.	8204.	7751.	7323.
6919.	6537.	6176.	5835.	5513.	5208.	4921.	4649.	4392.	4150.
3921.	3704.	3500.	3307.	3124.	2952.	2789.	2635.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13466.	13283.	11650.	7589.	283043.
INCHES		1.04	3.64	7.12	7.38
AC-FT		6590.	23120.	45179.	46808.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

0.	0.	0.	2.	14.	42.	129.	548.	1545.	3035.
4858.	6922.	9133.	11285.	13153.	14631.	15664.	16159.	15995.	15355.
14592.	13827.	13077.	12355.	11673.	11029.	10420.	9445.	9301.	8788.
8302.	7844.	7411.	7002.	6615.	6250.	5905.	5579.	5271.	4980.
4705.	4445.	4200.	3968.	3749.	3542.	3346.	3162.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16159.	15939.	13981.	9106.	339651.
INCHES		1.25	4.37	8.54	8.85
AC-FT		7908.	27744.	54215.	56170.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

0.	0.	0.	3.	16.	48.	150.	639.	1883.	3541.
5668.	8076.	10659.	13166.	15346.	17069.	18274.	18853.	18661.	17914.
17024.	16131.	15256.	14415.	13619.	12867.	12157.	11485.	10851.	10252.
9686.	9151.	8646.	8169.	7718.	7292.	6889.	6509.	6149.	5810.
5489.	5186.	4900.	4629.	4374.	4132.	3904.	3688.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18853.	18596.	16311.	10624.	396260.
INCHES		1.45	5.18	9.97	10.33
AC-FT		9226.	32368.	63250.	65531.

HYOROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

0.	0.	0.	3.	18.	55.	171.	731.	2060.	4047.
6478.	9230.	12177.	15047.	17538.	19508.	20885.	21546.	21327.	20473.
19456.	18436.	17435.	16474.	15564.	14705.	13893.	13126.	12401.	11717.
11070.	10459.	9881.	9336.	8820.	8333.	7873.	7439.	7028.	6640.
6273.	5927.	5600.	5290.	4998.	4722.	4462.	4215.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	21546.	21252.	18641.	12142.	452869.
INCHES		1.66	5.83	11.39	11.80
AC-FT		10544.	36992.	72286.	74893.

HYOROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

0.	0.	0.	4.	23.	69.	214.	913.	2575.	5058.
8097.	11537.	15222.	18808.	21922.	24385.	26106.	26932.	26658.	25592.
24320.	23045.	21794.	20592.	19455.	18381.	17366.	16408.	15582.	14646.
13837.	13073.	12352.	11670.	11025.	10417.	9841.	9298.	8785.	8308.
7842.	7409.	7000.	6613.	6248.	5903.	5577.	5269.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	26932.	26566.	23301.	15177.	566086.
INCHES		2.08	7.29	14.24	14.75
AC-FT		13180.	46241.	90358.	93616.

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HYOROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
2	1	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.000	0.00	1	1

HSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.000	0.000	0.000	-1.

STORAGE=	0.	867.	1734.	2601.	3468.	4335.	5202.	6069.	6936.	7803.
OUTFLOW=	0.	2138.	3972.	6342.	9148.	12330.	25451.	46828.	73667.	104967.

STATION 2, PLAN 1, RTIO 1

0.	0.	0.	0.	1.	2.	6.	23.	74.	178.
341.	558.	822.	1120.	1430.	1730.	1999.	2210.	2350.	2428.
2448.	2424.	2370.	2295.	2208.	2111.	2001.	1895.	1794.	1697.
1605.	1517.	1434.	1355.	1280.	1210.	1143.	1080.	1021.	964.
911.	861.	813.	768.	726.	686.	648.	612.		

STOR

0.	0.	0.	0.	0.	1.	2.	9.	30.	72.
[illegible]	[illegible]	[illegible]	454.	588.	702.	811.	901.	967.	1004.

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	2448.	2433.	2228.	1499.	55149.
	INCHES		.19	.78	1.41	1.44
	AC-FT		1287.	4422.	8925.	9128.

STATION 2, PLAN 1, RTIO 2

0.	0.	0.	0.	1.	4.	12.	46.	149.	357.
681.	1116.	1644.	2227.	2777.	3328.	3848.	4348.	4721.	4907.
4938.	4864.	4724.	4545.	4346.	4139.	3939.	3772.	3599.	3425.
3253.	3086.	2924.	2769.	2628.	2479.	2344.	2216.	2089.	1968.
1843.	1735.	1636.	1543.	1456.	1374.	1298.	1226.		

STOR

0.	0.	0.	0.	0.	2.	5.	19.	60.	145.
276.	452.	667.	989.	1169.	1438.	1672.	1872.	2088.	2076.
2087.	2068.	2089.	1944.	1871.	1795.	1718.	1639.	1558.	1475.
1394.	1315.	1239.	1165.	1095.	1028.	964.	904.	847.	795.
747.	704.	663.	626.	598.	557.	526.	497.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	4938.	4983.	4423.	2998.	118296.
	INCHES		.38	1.38	2.81	2.87
	AC-FT		2432.	8778.	17849.	18248.

STATION 2, PLAN 1, RTIO 3

0.	0.	0.	0.	2.	6.	18.	69.	223.	535.
1822.	1673.	2426.	3223.	4109.	5154.	6846.	6809.	7328.	7543.
7519.	7344.	7883.	6777.	6452.	6152.	5861.	5568.	5280.	5801.
4732.	4476.	4232.	4000.	3817.	3638.	3460.	3285.	3114.	2950.
2793.	2642.	2499.	2363.	2234.	2108.	1977.	1859.		

STOR

0.	0.	0.	0.	1.	2.	7.	28.	90.	217.
415.	679.	1003.	1380.	1784.	2167.	2493.	2745.	2906.	2972.
2965.	2911.	2830.	2735.	2635.	2531.	2425.	2318.	2212.	2110.
2012.	1918.	1829.	1744.	1661.	1576.	1492.	1409.	1329.	1251.
1177.	1105.	1038.	973.	912.	855.	802.	754.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	7543.	7469.	6787.	4496.	165485.
	INCHES		.58	2.10	4.22	4.31
	AC-FT		3785.	13318.	26767.	27354.

STATION 2, PLAN 1, RTIO 4

0.	0.	0.	0.	2.	8.	24.	92.	297.	714.
1363.	2228.	3152.	4303.	5728.	7124.	8379.	9334.	9980.	10199.
10098.	9807.	9416.	8995.	8579.	8152.	7729.	7318.	6923.	6546.
6207.	5903.	5601.	5388.	5024.	4753.	4495.	4249.	4016.	3829.
3650.	3472.	3296.	3125.	2961.	2803.	2652.	2508.		

STOR

0.	0.	0.	0.	1.	3.	10.	37.	121.	289.
553.	986.	1346.	1855.	2373.	2843.	3238.	3528.	3695.	3754.
3727.	3648.	3541.	3421.	3292.	3160.	3038.	2983.	2788.	2664.
2552.	2448.	2330.	2223.	2119.	2028.	1925.	1835.	1758.	1666.
1582.	1497.	1414.	1334.	1256.	1181.	1118.	1042.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	10199.	10892.	8999.	5989.	228338.
	INCHES		.79	2.81	5.62	5.74
	AC-FT		5887.	17859.	35656.	36437.

STATION 2, PLAN 1, RTIO 5

0.	0.	0.	0.	3.	9.	30.	115.	372.	892.
1784.	2718.	3894.	5576.	7489.	9178.	10777.	11933.	13809.	13869.
13412.	12889.	11685.	11174.	10635.	10048.	9552.	9067.	8595.	8140.

7715.	7298.	6901.	6523.	6187.	5882.	5581.	5288.	5005.	4734.
4477.	4232.	4000.	3817.	3638.	3459.	3284.	3114.		

STOR

0.	0.	0.	0.	1.	4.	12.	47.	151.	362.
691.	1137.	1697.	2321.	2931.	3474.	3912.	4227.	4380.	4384.
4340.	4272.	4159.	4021.	3873.	3724.	3578.	3437.	3297.	3159.
3025.	2896.	2774.	2657.	2544.	2433.	2323.	2215.	2112.	2013.
1919.	1829.	1744.	1661.	1576.	1492.	1409.	1328.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13068.	12830.	11301.	7484.	275247.
INCHES		1.00	3.53	7.02	7.17
AC-FT		6365.	22426.	44554.	45519.

STATION 2. PLAN 1, RTIO 6

0.	0.	0.	0.	3.	11.	36.	139.	446.	1070.
2044.	3200.	4795.	6856.	9120.	11338.	14195.	16103.	16074.	15638.
14900.	14132.	13376.	12642.	12168.	11788.	11293.	10753.	10204.	9664.
9144.	8692.	8243.	7805.	7385.	6983.	6601.	6251.	5947.	5644.
5349.	5063.	4790.	4530.	4282.	4048.	3863.	3676.		

STOR

0.	0.	0.	0.	1.	5.	15.	56.	181.	434.
829.	1369.	2035.	2760.	3459.	4065.	4458.	4584.	4582.	4553.
4505.	4454.	4404.	4356.	4291.	4187.	4052.	3905.	3756.	3609.
3467.	3327.	3188.	3053.	2923.	2799.	2681.	2568.	2456.	2346.
2239.	2133.	2033.	1938.	1848.	1762.	1678.	1594.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16103.	15936.	13637.	8981.	330267.
INCHES		1.25	4.26	8.42	8.61
AC-FT		7906.	27062.	53468.	54618.

STATION 2. PLAN 1, RTIO 7

0.	0.	0.	0.	4.	13.	42.	162.	520.	1249.
2355.	3699.	5723.	8244.	10950.	14877.	17983.	18628.	18771.	18234.
17384.	16488.	15605.	14750.	13935.	13166.	12439.	12088.	11660.	11144.
10597.	10049.	9513.	9013.	8561.	8115.	7683.	7267.	6871.	6495.
6164.	5859.	5558.	5266.	4984.	4715.	4458.	4214.		

STOR

0.	0.	0.	0.	1.	5.	17.	66.	211.	506.
970.	1605.	2374.	3189.	3959.	4583.	4709.	4751.	4761.	4725.
4669.	4610.	4551.	4495.	4441.	4390.	4342.	4269.	4152.	4012.
3863.	3713.	3568.	3426.	3287.	3149.	3015.	2887.	2765.	2648.
2536.	2424.	2314.	2207.	2104.	2006.	1912.	1823.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18771.	18544.	16022.	10485.	385497.
INCHES		1.45	5.01	9.84	10.04
AC-FT		9208.	31795.	62421.	63751.

STATION 2. PLAN 1, RTIO 8

0.	0.	0.	1.	4.	15.	48.	185.	595.	1427.
2655.	4257.	6675.	9658.	13312.	19103.	20318.	21315.	21458.	20839.
19867.	18843.	17835.	16857.	15926.	15047.	14216.	13431.	12689.	12187.
11818.	11327.	10789.	10239.	9699.	9177.	8721.	8271.	7833.	7411.
7008.	6625.	6272.	5967.	5664.	5368.	5082.	4808.		

STOR

0.	0.	0.	0.	2.	6.	20.	75.	241.	579.
1111.	1838.	2704.	3605.	4400.	4783.	4863.	4929.	4938.	4887.
4833.	4765.	4699.	4634.	4573.	4515.	4460.	4408.	4359.	4296.

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	21450.	21201.	18468.	11990.	440824.
	INCHES		1.66	5.77	11.25	11.49
	AC-FT		10518.	36650.	71382.	72901.

STATION 2, PLAN 1, RTIO 9

0.	0.	0.	1.	5.	19.	61.	231.	743.	1784.
3254.	5501.	8704.	12800.	21208.	23370.	25455.	26883.	26765.	25906.
24772.	23561.	22292.	21071.	19907.	18808.	17770.	16789.	15862.	14986.
14159.	13377.	12638.	12167.	11786.	11290.	10750.	10200.	9661.	9141.
8649.	8240.	7803.	7382.	6981.	6599.	6250.	5945.		

STOR

0.	0.	0.	0.	2.	8.	25.	94.	301.	723.
1394.	2294.	3331.	4366.	4922.	5065.	5202.	5260.	5255.	5220.
5157.	5077.	4993.	4913.	4836.	4763.	4694.	4630.	4568.	4511.
4456.	4404.	4355.	4291.	4187.	4052.	3904.	3755.	3608.	3466.
3326.	3187.	3052.	2922.	2798.	2680.	2567.	2456.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	26883.	26518.	23333.	14999.	551566.
	INCHES		2.07	7.30	14.07	14.37
	AC-FT		13156.	46305.	89297.	91215.

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

OPERATION	STATION	PLAN	RATIOS APPLIED TO FLOWS									
			.10	.20	.30	.40	.50	.60	.70	.80	1.00	
HYDROGRAPH AT	1	1	2693.	5386.	8080.	10773.	13466.	16159.	18853.	21546.	26932.	
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.	
ROUTED TO	2	1	2448.	4938.	7543.	10199.	13068.	16103.	18771.	21450.	26883.	
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.	

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**********
HEC-1 VERSION DATED JAN 1973
UPDATED AUG 74
CHANGE NO. 01
**********

                    PMF ROUTING - 307.25 - SPILLWAY CREST EL.
                    BOONTON DAM & PARSIPPANY DIKE
                    O'BRIEN & GERE - JUSTIN & COURTNEY DIV

                    JOB SPECIFICATION
                      MO   NNR  NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
                      48     2     0     1     0     0     0     2     0
                                       JOPER     NMT
                                          5       0

                    MULTI-PLAN ANALYSES TO BE PERFORMED
                        NPLAN= 1 NRTIO= 9 LRTIO= 1
          RTIOS=     .10   .20   .30   .40   .50   .60   .70   .80  1.00

**********  **********  **********  **********  **********

                    SUB-AREA RUNOFF COMPUTATION
                      ISTAQ   ICOMP   IECON   ITAPE   JPLT   JPRT   INAME
                        1       0       0       0       1      0      0

                    HYDROGRAPH DATA
          IHYDG   IUHG   TAREA   SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
            0       1   119.00   0.00    0.00    0.00   0.000     0       0       0

                    PRECIP DATA
                      MP   STORM     DAJ     DAK
                      12   0.00     0.00    0.00
                    PRECIP PATTERN
          0.00    0.00    0.00    .10     .20     .20    1.80    10.20   3.50    .40
          .30     .40

                    LOSS DATA
          STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
          0.00    0.00    1.00    0.00    0.00    1.00    0.00    0.00    0.00    0.00

                    UNIT HYDROGRAPH DATA
                    TP= 21.50    CP= .44    NTA= 0

                    RECESSION DATA
                      STRTQ=    0.00    QRCSN=    0.00    RTIOR= 1.00
 APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC=11.19 AND R=17.61 INTERVALS

          UNIT HYDROGRAPH100 END-OF-PERIOD ORDINATES, LAG=  21.56 HOURS, CP=  .44  VOL= 1.00
            40.     151.    311.    500.    712.    939.   1156.   1337.   1477.   1571.
          1611.    1574.   1491.   1400.   1331.   1257.   1188.   1122.   1060.   1002.
           946.     894.    845.    798.    754.    712.    673.    636.    601.    568.
           536.     507.    479.    452.    427.    404.    381.    360.    340.    322.
           304.     287.    271.    256.    242.    229.    216.    204.    193.    182.
           172.     163.    154.    145.    137.    130.    122.    116.    109.    103.
            98.      92.     87.     82.     78.     73.     69.     66.     62.     59.
            55.      52.     49.     47.     44.     42.     39.     37.     35.     33.
            31.      30.     28.     26.     25.     24.     22.     21.     20.     19.
            18.      17.     16.     15.     14.     13.     13.     12.     11.     11.
```

END-OF-PERIOD FLOW

	TIME	RAIN	EXCS	COMP Q
1	2 0	0.00	0.00	0.
1	4 0	0.00	0.00	0.
1	6 0	0.00	0.00	0.
1	8 0	.10	.10	4.
1	10 0	.20	.20	23.
1	12 0	.20	.20	69.
1	14 0	1.80	1.80	214.
1	16 0	10.20	10.20	913.
1	18 0	3.50	3.50	2575.
1	20 0	.40	.40	5058.
1	22 0	.30	.30	8097.
2	0 0	.40	.40	11537.
2	2 0	0.00	0.00	15222.
2	4 0	0.00	0.00	18008.
2	6 0	0.00	0.00	21922.
2	8 0	0.00	0.00	24305.
2	10 0	0.00	0.00	26106.
2	12 0	0.00	0.00	26932.
2	14 0	0.00	0.00	26658.
2	16 0	0.00	0.00	25592.
2	18 0	0.00	0.00	24320.
2	20 0	0.00	0.00	23045.
2	22 0	0.00	0.00	21794.
3	0 0	0.00	0.00	20592.
3	2 0	0.00	0.00	19455.
3	4 0	0.00	0.00	18381.
3	6 0	0.00	0.00	17366.
3	8 0	0.00	0.00	16408.
3	10 0	0.00	0.00	15502.
3	12 0	0.00	0.00	14646.
3	14 0	0.00	0.00	13837.
3	16 0	0.00	0.00	13073.
3	18 0	0.00	0.00	12352.
3	20 0	0.00	0.00	11670.
3	22 0	0.00	0.00	11025.
4	0 0	0.00	0.00	10417.
4	2 0	0.00	0.00	9841.
4	4 0	0.00	0.00	9298.
4	6 0	0.00	0.00	8785.
4	8 0	0.00	0.00	8300.
4	10 0	0.00	0.00	7842.
4	12 0	0.00	0.00	7409.
4	14 0	0.00	0.00	7000.
4	16 0	0.00	0.00	6613.
4	18 0	0.00	0.00	6248.
4	20 0	0.00	0.00	5903.
4	22 0	0.00	0.00	5577.
5	0 0	0.00	0.00	5269.
	SUM	17.10	17.10	566003.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	26932.	26566.	23301.	15177.	566086.
INCHES		2.08	7.29	14.24	14.75
AC-FT		13180.	46241.	90358.	93616.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

0.	0.	0.	0.	2.	7.	21.	91.	258.	506.
818.	1154.	1522.	1881.	2192.	2430.	2611.	2693.	2666.	2559.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2693.	2657.	2330.	1518.	56609.
INCHES		.21	.73	1.42	1.48
AC-FT		1310.	4624.	9036.	9362.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

0.	0.	0.	1.	5.	14.	43.	103.	515.	1012.
1619.	2307.	3044.	3762.	4384.	4877.	5221.	5386.	5332.	5118.
4864.	4609.	4359.	4110.	3891.	3676.	3473.	3282.	3100.	2929.
2767.	2615.	2470.	2334.	2205.	2083.	1968.	1860.	1757.	1660.
1568.	1482.	1400.	1323.	1250.	1181.	1115.	1054.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5306.	5313.	4660.	3035.	113217.
INCHES		.42	1.46	2.85	2.95
AC-FT		2636.	9248.	10072.	18729.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

0.	0.	0.	1.	7.	21.	64.	274.	773.	1519.
2429.	3461.	4566.	5643.	6577.	7315.	7832.	8080.	7997.	7678.
7296.	6913.	6538.	6170.	5837.	5514.	5210.	4922.	4651.	4394.
4151.	3922.	3705.	3501.	3308.	3125.	2952.	2789.	2635.	2490.
2352.	2223.	2100.	1984.	1874.	1771.	1673.	1581.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	8080.	7970.	6990.	4553.	169826.
INCHES		.62	2.19	4.27	4.43
AC-FT		3954.	13872.	27107.	28085.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

0.	0.	0.	2.	9.	28.	86.	365.	1030.	2023.
3239.	4615.	6009.	7523.	8769.	9754.	10442.	10773.	10663.	10237.
9720.	9218.	8718.	8237.	7782.	7353.	6947.	6563.	6201.	5858.
5535.	5229.	4941.	4668.	4410.	4167.	3937.	3719.	3514.	3320.
3137.	2963.	2800.	2645.	2499.	2361.	2231.	2108.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10773.	10626.	9320.	6071.	226434.
INCHES		.83	2.91	5.69	5.90
AC-FT		5272.	18496.	36143.	37446.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 5

0.	0.	0.	2.	12.	35.	107.	457.	1200.	2529.
4049.	5768.	7611.	9404.	10961.	12192.	13053.	13466.	13329.	12796.
12160.	11522.	10897.	10296.	9728.	9191.	8683.	8204.	7751.	7323.
6919.	6537.	6176.	5835.	5513.	5208.	4921.	4649.	4392.	4150.
3921.	3704.	3500.	3307.	3124.	2952.	2789.	2635.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13466.	13203.	11650.	7589.	283043.
INCHES		1.04	3.64	7.12	7.38
AC-FT		6590.	23120.	45179.	46808.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

0.	0.	0.	2.	14.	42.	129.	548.	1545.	3035.
4050.	6922.	9133.	11205.	13153.	14631.	15664.	16159.	15995.	15355.
14592.	13027.	13077.	12355.	11673.	11029.	10420.	9845.	9301.	8780.
8302.	7844.	7411.	7002.	6615.	6250.	5905.	5579.	5271.	4980.
4705.	4445.	4200.	3968.	3749.	3542.	3346.	3162.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16159.	15939.	13981.	9106.	339651.
INCHES		1.25	4.37	8.54	8.85
AC-FT		7900.	27744.	54215.	56170.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

0.	0.	0.	3.	16.	48.	150.	639.	1003.	3541.	
5668.	8076.	10655.	13166.	15346.	17069.	18274.	18853.	18661.	17914.	
17024.	16131.	15256.	14415.	13619.	12867.	12157.	11485.	10851.	10252.	
9686.	9151.	8646.	8169.	7718.	7292.	6889.	6509.	6149.	5810.	
5489.	5106.	4900.	4629.	4374.	4132.	3904.	3688.			

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18853.	18596.	16311.	10624.	396260.
INCHES		1.45	5.10	9.97	10.33
AC-FT		9226.	32368.	63250.	65531.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

0.	0.	0.	3.	18.	55.	171.	731.	2060.	4847.
6478.	9230.	12177.	15047.	17538.	19508.	20885.	21546.	21327.	20473.
19456.	18436.	17435.	16474.	15564.	14705.	13893.	13126.	12401.	11717.
11070.	10459.	9881.	9336.	8820.	8333.	7873.	7439.	7028.	6640.
6273.	5927.	5600.	5290.	4998.	4722.	4462.	4215.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	21546.	21252.	18641.	12142.	452069.
INCHES		1.66	5.83	11.39	11.80
AC-FT		10544.	36992.	72286.	74893.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

0.	0.	0.	4.	23.	69.	214.	913.	2575.	5058.
8097.	11537.	15222.	18808.	21922.	24385.	26106.	26932.	26658.	25592.
24320.	23045.	21794.	20592.	19455.	10381.	17366.	16400.	15502.	14646.
13837.	13073.	12352.	11670.	11025.	10417.	9041.	9290.	8785.	8300.
7842.	7409.	7000.	6613.	6248.	5903.	5577.	5269.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	26932.	26566.	23301.	15177.	566086.
INCHES		2.08	7.29	14.24	14.75
AC-FT		13180.	46241.	90358.	93616.

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HYDROGRAPH ROUTING

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
2	1	8	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.000	0.00	1	1

NSTPS	NSTOL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.000	0.000	0.000	-1.

STORAGE=	0.	867.	1734.	2601.	3468.	4335.	5202.	6069.	0.	0.
OUTFLOW=	0.	2150.	3982.	6352.	18761.	39495.	65744.	96486.	0.	0.

STATION 2, PLAN 1, RTIO 1

0.	0.	0.	0.	1.	2.	6.	23.	75.	179.
342.	560.	824.	1123.	1434.	1734.	2003.	2214.	2353.	2410.
2449.	2425.	2371.	2296.	2209.	2109.	2000.	1894.	1792.	1695.
1603.	1516.	1432.	1354.	1279.	1209.	1142.	1079.	1020.	963.
910.	860.	812.	768.	725.	685.	647.	612.		

STOR

0.	0.	0.	0.	0.	1.	2.	9.	30.	72.
138.	226.	332.	453.	570.	699.	808.	897.	963.	999.
1009.	997.	971.	936.	895.	851.	806.	764.	723.	684.
646.	611.	578.	546.	516.	487.	461.	435.	411.	388.
367.	347.	328.	310.	292.	276.	261.	247.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2449.	2435.	2229.	1499.	55159.
INCHES		.19	.70	1.41	1.44
AC-FT		1208.	4424.	8926.	9122.

STATION 2, PLAN 1, RTIO 2

0.	0.	0.	0.	1.	4.	12.	46.	149.	358.
684.	1119.	1649.	2233.	2780.	3331.	3842.	4347.	4720.	4906.
4937.	4863.	4724.	4545.	4346.	4139.	3941.	3773.	3608.	3426.
3254.	3087.	2925.	2769.	2621.	2479.	2344.	2216.	2087.	1958.
1841.	1734.	1634.	1541.	1454.	1373.	1296.	1224.		

STOR

0.	0.	0.	0.	0.	2.	5.	19.	60.	144.
276.	451.	665.	906.	1165.	1426.	1668.	1867.	2004.	2072.
2084.	2056.	2005.	1940.	1867.	1791.	1714.	1635.	1553.	1471.
1390.	1310.	1234.	1160.	1090.	1023.	959.	898.	842.	790.
742.	699.	659.	622.	587.	554.	523.	494.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4937.	4902.	4423.	2998.	110315.
INCHES		.38	1.38	2.81	2.87
AC-FT		2432.	8778.	17851.	18243.

STATION 2, PLAN 1, RTIO 3

0.	0.	0.	0.	2.	6.	18.	70.	224.	537.
1026.	1679.	2432.	3227.	4108.	5154.	6046.	7522.	8082.	7817.
7459.	7075.	6697.	6344.	6220.	6019.	5777.	5515.	5247.	4980.
4719.	4467.	4227.	3997.	3818.	3639.	3460.	3285.	3115.	2951.
2793.	2643.	2500.	2364.	2234.	2106.	1976.	1857.		

STOR

0.	0.	0.	0.	1.	2.	7.	28.	90.	217.
414.	677.	1001.	1377.	1780.	2163.	2489.	2683.	2722.	2703.
2678.	2652.	2625.	2598.	2553.	2479.	2391.	2295.	2197.	2099.
2004.	1912.	1823.	1739.	1656.	1572.	1487.	1404.	1324.	1246.
1171.	1100.	1032.	968.	907.	849.	797.	749.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	8082.	7807.	6714.	4496.	165433.
INCHES		.61	2.10	4.22	4.31
AC-FT		3873.	13325.	26770.	27358.

STATION 2, PLAN 1, RTIO 4

0.	0.	0.	0.	2.	8.	24.	93.	299.	716.
1368.	2227.	3156.	4304.	5720.	8331.	10246.	10638.	10725.	10427.
9945.	9433.	8929.	8440.	7974.	7533.	7117.	6724.	6353.	6233.
6035.	5795.	5533.	5264.	4997.	4736.	4484.	4242.	4011.	3829.
3650.	3472.	3296.	3126.	2961.	2803.	2652.	2509.		

STOR

0.	0.	0.	0.	1.	3.	10.	37.	120.	289.
552.	904.	1343.	1852.	2370.	2739.	2873.	2900.	2907.	2886.
2852.	2816.	2781.	2747.	2714.	2684.	2654.	2627.	2601.	2558.
2485.	2397.	2301.	2203.	2105.	2010.	1918.	1829.	1745.	1662.
1577.	1493.	1410.	1329.	1251.	1176.	1105.	1037.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10725.	10597.	9145.	5990.	220362.
INCHES		.83	2.86	5.62	5.74
AC-FT		5257.	18148.	35659.	36442.

STATION 2, PLAN 1, RTIO 5

0.	0.	0.	0.	3.	10.	30.	116.	373.	895.
1710.	2716.	3898.	5577.	9064.	11787.	12693.	13307.	13405.	13034.
12471.	11709.	11141.	10569.	9962.	9417.	8897.	8408.	7961.	7587.

7089.	6697.	6344.	6219.	6018.	5776.	5514.	5245.	4978.	4718.
4466.	4225.	3996.	3817.	3638.	3459.	3284.	3114.		

STOR

0.	0.	0.	0.	1.	4.	12.	47.	151.	361.
689.	1135.	1694.	2317.	2790.	2981.	3044.	3087.	3894.	3068.
3026.	2981.	2937.	2894.	2854.	2815.	2779.	2744.	2712.	2681.
2652.	2625.	2598.	2552.	2479.	2390.	2294.	2196.	2098.	2003.
1911.	1823.	1739.	1656.	1571.	1487.	1404.	1323.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	13405.	13249.	11551.	7484.	275277.
INCHES		1.04	3.61	7.02	7.17
AC-FT		6573.	22922.	44556.	45524.

STATION 2, PLAN 1, RTIO 6

0.	0.	0.	0.	3.	11.	36.	139.	448.	1075.
2052.	3205.	4797.	7644.	12602.	14000.	15243.	15968.	16086.	15641.
14918.	14150.	13393.	12659.	11960.	11300.	10676.	10087.	9530.	9004.
8507.	8037.	7593.	7174.	6778.	6404.	6249.	6062.	5827.	5569.
5301.	5033.	4771.	4518.	4275.	4043.	3853.	3675.		

STOR

0.	0.	0.	0.	1.	5.	15.	56.	181.	433.
827.	1366.	2032.	2691.	3038.	3135.	3222.	3273.	3281.	3250.
3199.	3146.	3093.	3042.	2993.	2947.	2903.	2862.	2823.	2786.
2752.	2719.	2688.	2658.	2631.	2605.	2563.	2495.	2409.	2314.
2217.	2119.	2023.	1930.	1841.	1756.	1673.	1589.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	16086.	15898.	13993.	8981.	330297.
INCHES		1.24	4.38	8.42	8.61
AC-FT		7887.	27770.	53470.	54623.

STATION 2, PLAN 1, RTIO 7

0.	0.	0.	0.	4.	13.	43.	162.	522.	1254.
2363.	3704.	5724.	11210.	14511.	16350.	17783.	18629.	18769.	18246.
17404.	16508.	15625.	14769.	13954.	13183.	12455.	11768.	11118.	10504.
9924.	9376.	8859.	8370.	7908.	7471.	7058.	6669.	6335.	6204.
5999.	5755.	5493.	5224.	4958.	4698.	4447.	4207.		

STOR

0.	0.	0.	0.	1.	5.	17.	65.	211.	506.
868.	1602.	2371.	2940.	3171.	3300.	3400.	3459.	3468.	3432.
3373.	3311.	3249.	3189.	3132.	3078.	3027.	2979.	2934.	2891.
2851.	2812.	2776.	2742.	2710.	2679.	2650.	2623.	2595.	2547.
2472.	2383.	2287.	2188.	2091.	1996.	1904.	1816.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	18769.	18548.	16311.	10485.	385530.
INCHES		1.45	5.10	9.84	10.05
AC-FT		9202.	32369.	62423.	63757.

STATION 2, PLAN 1, RTIO 8

0.	0.	0.	1.	4.	15.	49.	186.	597.	1433.
2662.	4259.	7182.	14151.	16472.	18695.	20674.	21393.	21450.	20719.
19717.	18705.	17871.	16878.	15947.	15067.	14235.	13449.	12706.	12005.
11342.	10716.	10124.	9565.	9037.	8538.	8067.	7621.	7201.	6803.
6427.	6257.	6075.	5843.	5585.	5318.	5051.	4788.		

STOR

0.	0.	0.	0.	2.	6.	20.	75.	241.	578.
1109.	1835.	2659.	3146.	3308.	3463.	3548.	3578.	3580.	3550.
3508.	3464.	3406.	3336.	3271.	3210.	3152.	3097.	3045.	2996.

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	21450.	21188.	14632.	11991.	440880.
	INCHES		1.66	5.83	11.25	11.49
	AC-FT		10512.	36976.	71388.	72910.

STATION 2, PLAN 1, RTIO 9

0.	0.	0.	1.	5.	19.	61.	232.	746.	1791.
3260.	5503.	12392.	17402.	21031.	23850.	25703.	26787.	26798.	25984.
24645.	23367.	22109.	20893.	19739.	18670.	17807.	16810.	15883.	15006.
14178.	13395.	12655.	11957.	11296.	10673.	10084.	9527.	9001.	8504.
8034.	7591.	7172.	6776.	6402.	6249.	6061.	5826.		

STOR

0.	0.	0.	0.	2.	8.	25.	94.	301.	722.
1392.	2291.	3023.	3373.	3563.	3681.	3758.	3804.	3804.	3767.
3714.	3661.	3608.	3557.	3509.	3462.	3401.	3332.	3267.	3206.
3148.	3093.	3041.	2993.	2946.	2903.	2862.	2823.	2786.	2751.
2719.	2688.	2658.	2631.	2604.	2563.	2495.	2409.		

		PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
	CFS	26798.	26496.	23291.	15005.	551792.
	INCHES		2.07	7.28	14.08	14.38
	AC-FT		13145.	46221.	89331.	91252.

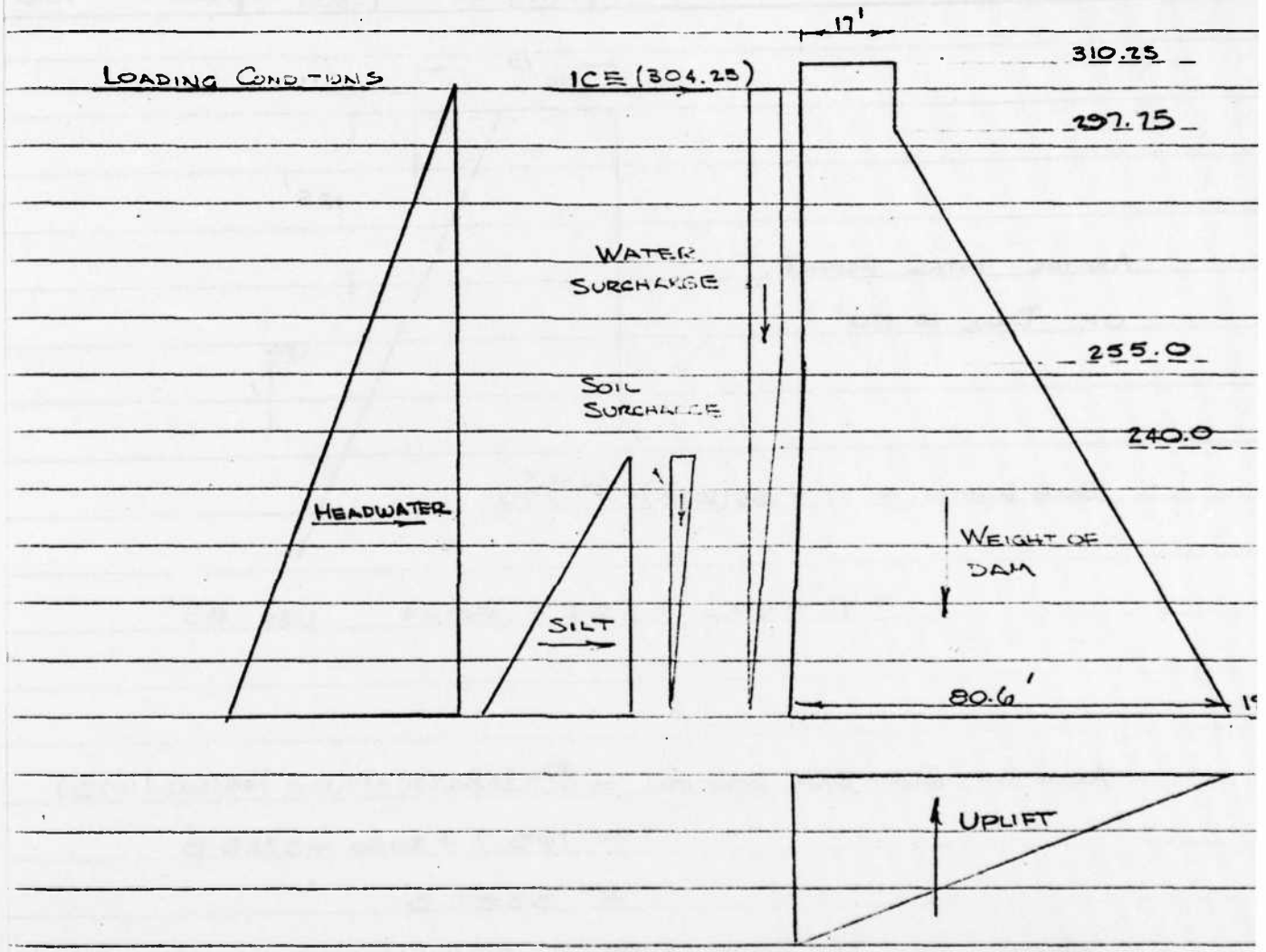
PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

ERATION	STATION	PLAN	RATIOS APPLIED TO FLOWS									
			.15	.20	.30	.40	.50	.60	.70	.80	1.00	
DROGRAPH AT	1	1	2693.	5386.	8080.	10773.	13466.	16159.	18853.	21546.	26932.	
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.	
UTED TO	2	1	2449.	4937.	8082.	10725.	13405.	16086.	18769.	21450.	26798.	
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.	

STABILITY ANALYSES

O'BRIEN&GERE ENGINEERS

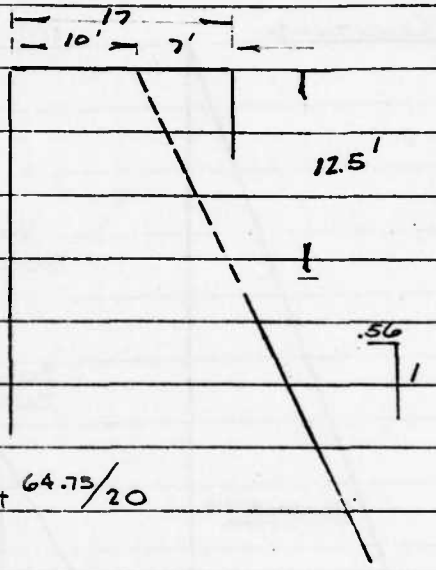
SUBJECT	SHEET	BY	DATE	JOB NO
BOUNTON RESERVOIR DAM	1	ZEH	5/3/78	1800 (80) 195



- SEISMIC LOADINGS APPLIED: HORIZONTAL INERTIAL FORCES DEVELOPED BY THE WEIGHT OF THE DAM AND THE HYDROSTATIC LOADING. INCLUSION OF THE SEISMIC SILT LOADING HAS A NEGLIBLE EFFECT ON THE RESULTS AND HAS BEEN OMITTED FROM THE ANALYSES.
- SLIDING PLANE: FOR SIMPLIFICATION OF THE ANALYSES, THE DAM SECTION HAS BEEN EXTENDED DOWN TO THE APPROXIMATE BASE ELEVATION OF THE SHEAR KEY.

O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
Boonton Reservoir Dam	1A	REL	5/3/78	19



Assume Total Height of Dam = 120'

∴ Base Width = $17' + .56(107.5) + 64.75/20$

$= 17' + 60.2' + 3.24 = 80.44$ Use 80'

Area of Max Dam Section $= \frac{1}{2}(3.24)(65.25) + 17(120) + \frac{1}{2}(60.2)(107.5)$

$= 105.7 + 2040 + 3235.8$

$= 5381.5$

Weight of Dam/unit length = 893.3 Kips

$C.G. = \dfrac{105.7(78.28) + 2040(68.7) + 3235.8(40.13)}{5381.5}$

C.G. = 51.7' upstream of Toe

O'BRIEN & GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO.
BOONTON RESERVOIR DAM	2	REH	5/3/78	1800.001

ANALYSES ASSUMPTIONS:

UNIT WEIGHT OF MASONRY - 166 PCF

UNIT WEIGHT OF SILT - 86 PCF

SILT, INTERNAL ∠ of FRICTION - 30°

ICE PRESSURE - 5 KSF

∠ OF FRICTION, MASONRY/FOUNDATION - 30°

SHEAR RESISTANCE, MASONRY/FOUNDATION - 100 PSI

SEISMIC COEFF. OF ACCELERATION - .05g

ALLOWABLE BEARING CAPACITY - 200 PSI

ALLOWABLE TENSILE STRESS - 25 PSI

ASSUMPTIONS HAVE BEEN BASED ON FURNISHED DATA AND GENERALIZED SITE CONDITIONS.

MORE COMPREHENSIVE ANALYSIS OF THE EXISTING DAM AND FOUNDATION MAY REVEAL A MORE CRITICAL STRUCTURAL CONDITION.

O'BRIEN&GERE ENGINEERS

SUBJECT	SHEET	BY	DATE	JOB NO
BOONTON RESERVOIR DAM	3	REH	5/3/78	1900 001

STABILITY ANALYSES - SUMMARY

LOADING CONDITION	S.F. - OVERTURNING	S.F. - SLIDING	BEARING PRESSURE
NORMAL POOL	1.50	3.39	113.4 psi
			- 5.0 psi
NORMAL POOL - ICE	1.50	3.43	115.5 psi
			- 6.3 psi
NORMAL POOL - PMF	1.36	3.06	130.4 psi
			- 24.7 psi
NORMAL POOL - EARTHQUAKE	1.37	2.94	133.1 psi
			- 24.7 psi
RAISED POOL	1.45	3.28	118.7 psi
			- 11.2 psi
RAISED POOL - PMF	1.35	3.05	131.5 psi
			- 25.9 psi
RAISED POOL - EARTHQUAKE	1.33	2.86	138.7 psi
			- 31.2 psi

NORMAL POOL ELEV (BASCULE GATES DOWN) - 305.25

RAISED POOL ELEV (BASCULE GATES UP) - 307.25

Negative bearing pressures indicate tension at the upstream face.

NATIONAL DAM INSPECTION PROGRAM - BOONTON RESERVOIR DAM
STABILITY ANALYSIS, FULL SECTION, NORMAL POOL -EL =305.25

BASE ELEVATION= 190.00FT. TOP ELEVATION= 310.25FT. BASE WIDTH= 80.60FT. DENSITY= 166.00PCF
HEADWATER ELEVATION= 305.25FT. TAILWATER ELEVATION= 0.00FT. EARTHQUAKE ACCELERATION***.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 240.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 100.00*SI SHEAR WIDTH= 80.60FT. FRICTION FACTOR= .58

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	496.43	51.79	46421.74	
HEADWATER	414.42	38.38		15904.56
UPLIFT	289.82	53.73		15573.07
SILT	35.80	16.67		596.63
WATER SURCHARGE	16.80	79.20	1330.56	
SOIL SURCHARGE	5.40	79.80	430.92	
			48183.22	32074.26

NET HORIZONTAL FORCE= 450.21 KIPS
NET VERTICAL FORCE= 628.81 KIPS
NET MOMENT= 16108.96KIP-FEET
X-BAR OF FOUNDATION REACTION= 25.62 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 14.68 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
FOUNDATION REACTION PRESSURES********TOE= 113.39 PSI********HEEL= -5.03 PSI********
OVERTURNING FACTOR OF SAFETY= 1.50
SLIDING FACTOR OF SAFETY= .81
DEVELOPED FRICTION FACTOR (NO SHEAR)= .72
SLIDING WITH SHEAR FACTOR OF SAFETY= 3.39(SHEAR ACROSS FULL BASE WIDTH)

NATIONAL DAM INSPECTION PROGRAM - BOONTON RESERVOIR DAM
STABILITY ANALYSIS, FULL SECTION, NORMAL POOL -PMF

BASE ELEVATION= 190.00FT. TOP ELEVATION= 310.25FT. BASE WIDTH= 80.60FT. DENSITY= 166.00PCF
HEADWATER ELEVATION= 311.30FT. TAILWATER ELEVATION= 0.00FT. EARTHQUAKE ACCELERATION***.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 240.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 100.00PSI SHEAR WIDTH= 80.60FT. FRICTION FACTOR= .58

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	896.43	51.79	46421.74	
HEADWATER	459.03	40.43		18557.47
UPLIFT	305.04	53.73		16390.58
SILT	35.80	16.67		596.63
WATER SURCHARGE	16.80	79.20	1330.56	
SOIL SURCHARGE	5.40	79.80	430.92	
			*********	*********
			48183.22	35544.67

NET HORIZONTAL FORCE= 494.83 KIPS
NET VERTICAL FORCE= 613.59 KIPS
NET MOMENT= 12638.55KIP-FEET
X-BAR OF FOUNDATION REACTION= 20.60 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 19.70 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
FOUNDATION REACTION PRESSURES********TOE= 130.40 PSI********HEEL= -24.67 PSI********
OVERTURNING FACTOR OF SAFETY= 1.36
SLIDING FACTOR OF SAFETY= .72
DEVELOPED FRICTION FACTOR (NO SHEAR)= .81
SLIDING WITH SHEAR FACTOR OF SAFETY= 3.06(SHEAR ACROSS FULL BASE WIDTH)

****

NATIONAL DAM INSPECTION PROGRAM - BOONTON RESERVOIR DAM
STABILITY ANALYSIS: FULL SECTION; NORMAL POOL - ICE LOADING

****

BASE ELEVATION= 190.00FT. TOP ELEVATION= 310.25FT. BASE WIDTH= 80.60FT. DENSITY= 166.00PCF
HEADWATER ELEVATION= 303.25FT. TAILWATER ELEVATION= 0.00FT. EARTHQUAKE ACCELERATION=***.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 240.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 100.00PSI SHEAR WIDTH= 80.60FT. FRICTION FACTOR= .58

****

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	896.43	51.79	46421.74	
HEADWATER	400.16	37.71		15090.84
UPLIFT	284.79	53.73		15302.83
SILT	35.80	16.67		596.63
ICE LOADING	10.00	114.25		1142.50
WATER SURCHARGE	16.60	79.20	1330.56	
SOIL SURCHARGE	5.40	79.80	430.92	
			*********	*********
			48183.22	32132.79

****

NET HORIZONTAL FORCE= 445.96 KIPS
NET VERTICAL FORCE= 533.83 KIPS
NET MOMENT= 16050.43KIP-FEET
X-BAR OF FOUNDATION REACTION= 25.32 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 14.98 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
FOUNDATION REACTION PRESSURES*******TOE=-115.50 PSI*******HEEL= -6.28 PSI********
OVERTURNING FACTOR OF SAFETY= 1.50
SLIDING FACTOR OF SAFETY= .82
DEVELOPED FRICTION FACTOR (NO SHEAR)= .70
SLIDING WITH SHEAR FACTOR OF SAFETY= 3.43(SHEAR ACROSS FULL BASE WIDTH)

NATIONAL DAM INSPECTION PROGRAM - BOONTON RESERVOIR DAM
STABILITY ANALYSIS, FULL SECTION, NORMAL POOL-EARTHQUAKE

BASE ELEVATION= 190.00FT. TOP ELEVATION= 310.25FT. BASE WIDTH= 80.60FT. DENSITY= 166.00PCF
HEADWATER ELEVATION= 305.25FT. TAILWATER ELEVATION= 0.00FT. EARTHQUAKE ACCELERATION=.050G (HORIZ)..000G (VERT)
SILT ELEVATION= 240.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 100.00PSI SHEAR WIDTH= 80.60FT. FRICTION FACTOR= .58

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	896.43	51.79	46421.74	
HEADWATER	414.42	38.38		15904.56
UPLIFT	289.82	53.73		15573.07
EARTHQUAKE INDUCED LOADINGS				
INERTIA-WATER	23.06	46.10		1063.30
HORIZONTAL INERTIA-DAM	44.82	44.80		2007.90
SILT	35.80	16.67		596.63
WATER SURCHARGE	16.80	79.20	1330.56	
SOIL SURCHARGE	5.40	79.80	430.92	
			48183.22	35145.45

NET HORIZONTAL FORCE= 518.10 KIPS
NET VERTICAL FORCE= 328.81 KIPS
NET MOMENT= 13037.77KIP-FEET
X-BAR OF FOUNDATION REACTION= 20.73 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 19.57 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
FOUNDATION REACTION PRESSURES********TOE= 133.09 PSI********HEEL= -24.73 PSI********
OVERTURNING FACTOR OF SAFETY= 1.37
SLIDING FACTOR OF SAFETY= .70
DEVELOPED FRICTION FACTOR (NO SHEAR)= .82
SLIDING WITH SHEAR FACTOR OF SAFETY= 2.94(SHEAR ACROSS FULL BASE WIDTH)

NATIONAL DAM INSPECTION PROGRAM - BOONTON RESERVOIR DAM
STABILITY ANALYSIS; FULL SECTION; POOL ELEVATION =307.25

BASE ELEVATION= -190.00FT. TOP ELEVATION= 310.25FT. BASE WIDTH= 80.60FT. DENSITY= 166.00PCF
HEADWATER ELEVATION= 307.25FT. TAILWATER ELEVATION= 0.00FT. EARTHQUAKE ACCELERATION=.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 240.00FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 100.00PSI SHEAR WIDTH= 80.60FT. FRICTION FACTOR= .58

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	896.43	51.79	46421.74	
HEADWATER	428.92	39.04		16747.01
UPLIFT	294.85	53.73		15843.32
SILT	35.80	16.67		596.63
WATER SURCHARGE	17.20	79.30	1363.96	
SOIL SURCHARGE	5.40	79.80	430.92	
			48216.62	33186.96

NET HORIZONTAL FORCE= 464.72 KIPS
NET VERTICAL FORCE= 524.18 KIPS
NET MOMENT= 15029.66KIP-FEET
X-BAR OF FOUNDATION REACTION= 24.08 FEET
ECCENTRIGITY OF FOUNDATION REACTION FROM CENTER= 16.22 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
FOUNDATION REACTION PRESSURES********TOE= 118.72 PSI********HEEL= -11.16 PSI********
OVERTURNING FACTOR OF SAFETY= 1.49
SLIDING FACTOR OF SAFETY= .78
DEVELOPED FRICTION FACTOR (NO SHEAR)= .74
SLIDING WITH SHEAR FACTOR OF SAFETY= 3.28(SHEAR ACROSS FULL BASE WIDTH)

NATIONAL DAM INSPECTION PROGRAM - BOONTON RESERVOIR DAM
STABILITY ANALYSIS, FULL SECTION, POOL EL -307.25 -PMF

BASE ELEVATION= 190.00FT. TOP ELEVATION= 310.25FT. BASE WIDTH= 80.60FT. DENSITY= 166.00PCF
HEADWATER ELEVATION= 311.70FT. TAILWATER ELEVATION= 0.00FT. EARTHQUAKE ACCELERATION***.000G (HORIZ)..000G (VERT)
SILT ELEVATION= 240.00FT. SILT DENSITY(SUBMERGED)= 66.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 100.00PSI SHEAR WIDTH= 80.60FT. FRICTION FACTOR= .58

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	896.43	51.79	46421.74	
HEADWATER	462.03	40.56		18737.93
UPLIFT	306.04	53.73		16444.63
SILT	35.80	16.67		596.63
WATER SURCHARGE	17.20	79.30	1363.96	
SOIL SURCHARGE	5.40	79.80	430.92	
			48216.62	35779.18

NET HORIZONTAL FORCE= 497.83 KIPS
NET VERTICAL FORCE= 612.99 KIPS
NET MOMENT= 12437.44KIP-FEET
X-BAR OF FOUNDATION REACTION= 20.29 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 20.01 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
FOUNDATION REACTION PRESSURES*******TOE= 131.49 PSI*******HEEL= -25.86 PSI*******
OVERTURNING FACTOR OF SAFETY= 1.35
SLIDING FACTOR OF SAFETY= .71
DEVELOPED FRICTION FACTOR (NO SHEAR)= .81
SLIDING WITH SHEAR FACTOR OF SAFETY= 3.05(SHEAR ACROSS FULL BASE WIDTH)

NATIONAL DAM INSPECTION PROGRAM - BOONTON RESERVOIR DAM
STABILTY ANALYSIS, FULL SECTION, POOL EL =307.25 =EARTHQUAKE

BASE ELEVATION= 190.00FT. TOP ELEVATION= 310.25FT. BASE WIDTH= 80.60FT. DENSITY= 166.00PCF
HEADWATER ELEVATION= 307.25FT. TAILWATER ELEVATION= 0.00FT. EARTHQUAKE ACCELERATION***.050G (HORIZ),.000G (VERT)
SILT ELEVATION= 240.10FT. SILT DENSITY(SUBMERGED)= 86.00PCF SILT PRESSURE COEFFICIENT(K)= .33
SHEAR STRESS= 100.00PSI SHEAR WIDTH= 80.60FT. FRICTION FACTOR= .58

LOADING	FORCE(KIPS)	ARM(FEET)	STABILIZING MOMENT	OVERTURNING MOMENT
WEIGHT OF DAM	896.43	51.79	46421.74	
HEADWATER	428.92	39.04		16747.01
UPLIFT	294.85	53.73		15843.32
EARTHQUAKE INDUCED LOADINGS				
**********				
INERTIA-WATER	23.67	46.90		1110.03
HORIZONTAL INERTIA-DAM	44.82	44.80		2007.90
**********				
SILT	35.80	16.67		596.63
WATER SURCHARGE	17.20	79.30	1363.96	
SOIL SURCHARGE	5.40	79.80	430.92	
			*********	*********
			48216.62	36304.89

NET HORIZONTAL FORCE= 533.21 KIPS
NET VERTICAL FORCE= 524.18 KIPS
NET MOMENT= 11911.73KIP-FEET
X-BAR OF FOUNDATION REACTION= 19.08 FEET
ECCENTRICITY OF FOUNDATION REACTION FROM CENTER= 21.22 FEET
**********FOUNDATION REACTION NOT IN CENTRAL THIRD OF BASE*****TENSION AT HEEL OF DAM*****
FOUNDATION REACTION PRESSURES********TOE= 138.71 PSI********HEEL= -31.16 PSI********
OVERTURNING FACTOR OF SAFETY= 1.33
SLIDING FACTOR OF SAFETY= .68
DEVELOPED FRICTION FACTOR (NO SHEAR)= .85
SLIDING WITH SHEAR FACTOR OF SAFETY= 2.66(SHEAR ACROSS FULL BASE WIDTH)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